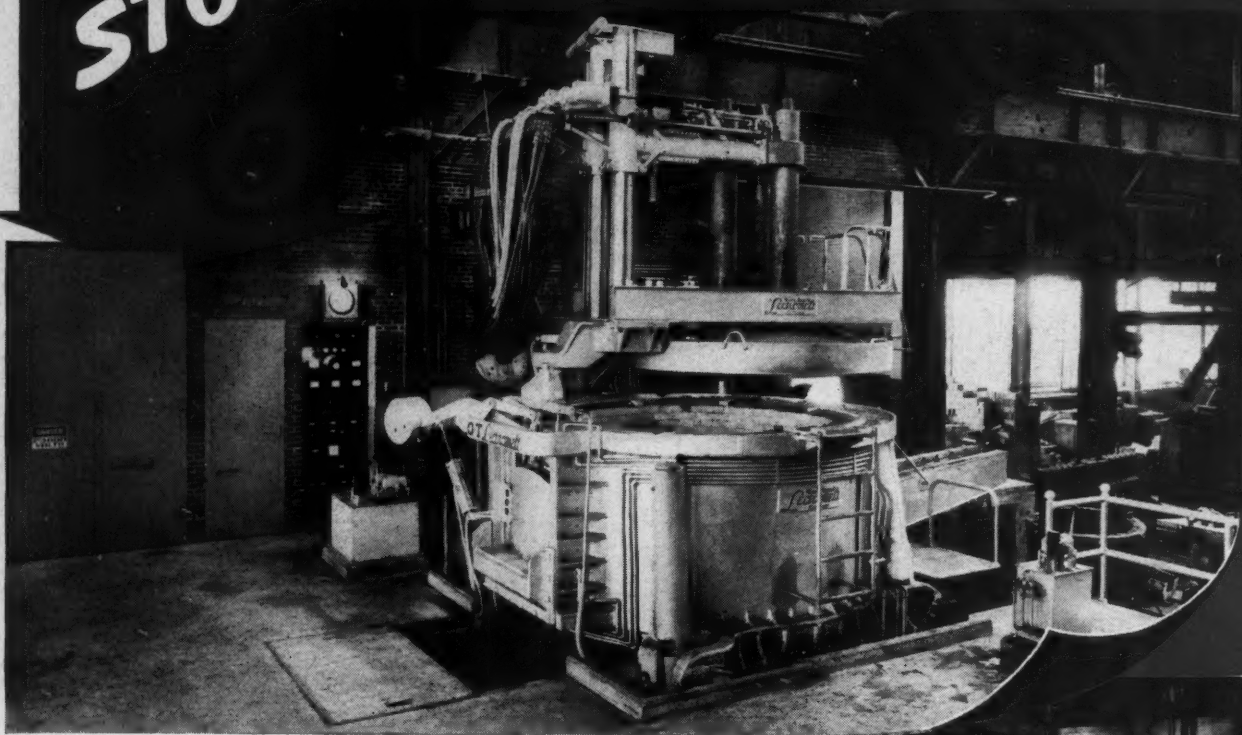
American Foundryman

★ THE FOUNDRYMEN'S OWN MAGAZINE

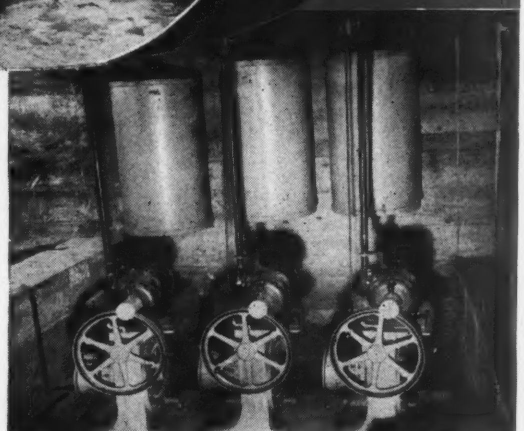
SEPTEMBER 1946

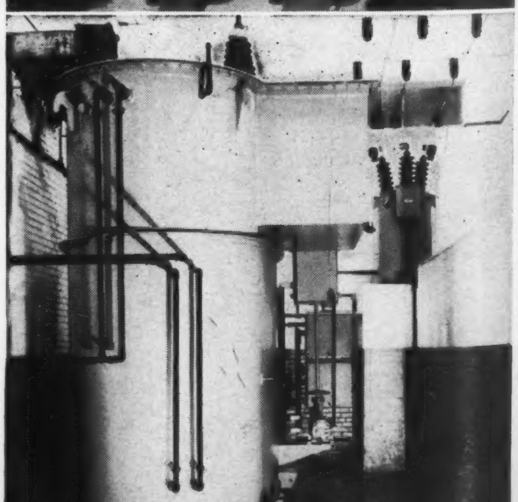
THE INSIDE STORY OF MELTING ECONOMY

MOORE RAPID *Lectromelt* FURNACES



Size "O.T." Lectromelt Furnace with roof swung aside in charging position.





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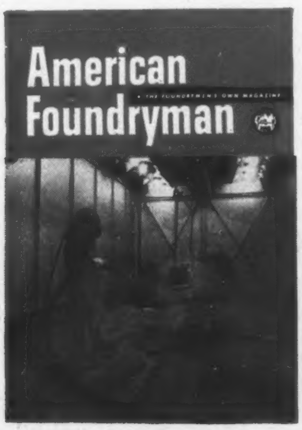

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This Month's Cover

Putting the finishing touch on a steel casting in a well illuminated and ventilated shot blast room. The man dressed in protective clothing is shot blasting a large steel casting.

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★ SEPTEMBER WHO'S WHO ★

J. M. Diebold

J. M. Diebold is co-author of the paper *"Cast Iron Repair Welding Metallurgical Aspects"* . . . Written with J. A. Griffin and J. A. Blastic . . . Mr. Diebold was born in Colorado . . . Attended the University of Colorado, Boulder, and graduated in 1932 with a Bachelor of Science degree in mechanical arts . . . Joined the engineering division of the Chrysler Corp., Detroit (1933), serving as laboratory engineer and later as welding engineer . . . In 1941 became associated with Yellow Truck & Coach Mfg. Co., Pontiac, as welding engineer . . . This organization later became GMC Truck & Coach Div., General Motors Corp. . . . At present is head of the welding engineering department of this organization.

Ralph L. Lee

The introduction of *"A Simple Cost System For Small Foundries"* is accomplished by Mr. Lee in this issue . . . Associated with Grede Foundries, Inc., Milwaukee, as comptroller, Mr. Lee has long been active in the study of foundry costs . . .Born on a farm near Macon, Ill., in 1890 . . . Early schooling in Decatur, Ill., and studied law there at James Millikin University . . . Later studied accounting in Chicago . . . First position, assistant purchasing agent, Mueller Co., Decatur . . . Connected with a number of national organizations in various capacities . . . From 1917-20, held position of office manager, Wagner Malleable Iron Co., Decatur . . . Became secretary-treasurer at Liberty Foundry Co., Milwaukee, in 1920, where he served for 20 years . . . When Liberty merged with Grede in 1940, appointed to present position . . . Since 1935 has served as Chairman, A. F. A. Foundry Cost Committee . . . Also served on Cost Committee of Gray Iron Founders Society . . . Has participated in activities of A. F. A. Cost Committee in publication of numerous studies, including comparison of foundry cost factors for steel, malleable, gray iron and non-ferrous foundries . . . Is a frequent and popular speaker before A. F. A. chapters, conventions and other gatherings.

J. A. Griffin

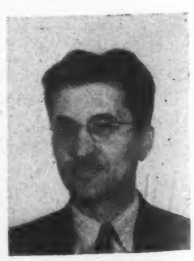
Co-author, with Messrs. Diebold and Blastic, of *"Cast Iron Repair Welding Metallurgical Aspects"* . . . Mr. Griffin is a native of Murphysboro, Ill. . . . Entered the casting industry as a foundry worker with Harrison Iron Works, Murphysboro, in 1918 . . . Moved to Detroit where he became associated with Motor Products as an inspector (1920) . . . Later, 1923, went with Graham Paige Motor Corp., Detroit, in the capacity of inspector . . . In 1923 advanced to the position of assistant foundry engineer with the same firm . . . Joined Pontiac Motor Co., Pontiac, Mich., in 1937, as supervisor of welding and salvage, his present position . . . Member of A. F. A., Mr. Griffin assisted in the writing of welding procedure accepted by the War Engineering board.

W. J. Hebard

Training programs have long been of interest to W. J. Hebard, personnel director, Continental Foundry & Machine Co., East Chicago, Ind. . . . In his paper *"Accelerated Training"* the author gives pertinent data concerning new types of training programs . . . Born in Milwaukee, Mr. Hebard attended Marquette University, Milwaukee . . . Graduated in 1925 with an electrical engineering degree . . . As a member of Falk Corp., Milwaukee, he began his industrial career as assistant apprentice supervisor (1925-26) . . . From 1926-28 was associated with International Correspondence School, Scranton, Pa., in the apprentice training division . . . At Marquette University, college of engineering, the author assumed the position of director of industrial relations (1928-42) . . . In 1942, returning to industry, Mr. Hebard was named personnel director, Continental Foundry & Machine Co., East Chicago, Ind. . . . Has written papers for annual meetings of the A.F.A. concerning apprenticeship and training . . . A member of the American Apprenticeship Round Table.

H. W. Hershey

H. W. Hershey, instructor, foundry and patternmaking, Revere Trade School, Rochester, N. Y., is the author of *"Foundry and Patternmaking in a Trade School"* . . . Born in Ontario County, N. Y. . . . Attended and graduated from State Teachers College, Oswego, N. Y. . . . Was a graduate student at Syracuse University, Syracuse, N. Y. . . . Entered the castings industry as apprentice molder, American Laundry Machinery Co., Rochester, N. Y., and remained with that firm three years . . . Served his patternmaking apprenticeship at the Gleason Works, Rochester, N. Y., and was a member of that organization for 12 years . . . First teaching assignment was instructor in foundry and patternmaking at Blodgett Vocational High School, Syracuse, N. Y. . . . Following a three year affiliation he severed his connection in 1940 . . . A.F.A. member.



O. Tichy

See: *"Aluminum Casting Alloy 3 per cent Cu: 5 per cent Si"* . . . Author Oldrich Tichy, was born in Cleveland . . . Received his Bachelor of Arts degree in 1929 from Western Reserve University, Cleveland . . . In 1933 he became

associated with National Smelting Co., Cleveland, as chemist . . . Four years later (1937) was named metallurgist . . . Obtained his Master of Science degree from the Case School of Applied Science, Cleveland, in 1942 . . . Is a member of AIME, ASM, and American Foundrymen's Association.

G. E. Dalbey

Mr. Dalbey, whose article on *"Non-Ferrous Alloy Castings Gas Elimination"* appears in this issue, is metallurgist, Mare Island Naval Shipyard, Mare Island, Calif. . . . The author attended University of Kansas City, Kansas City, Mo., and majored in chemistry . . . Later took a course in physical chemistry and metallurgy at University of California, Berkeley . . . In 1910 he joined American Smelting & Refining Co., Omaha, Neb., as research chemist and metallurgist . . . Eight years later (1918) became associated with Eastern Brass & Ingot Corp., Waterbury, Conn., as chief chemist and metallurgical superintendent . . . From 1922-30 was connected with Stanley Chemical Co., East Berlin, Conn., in the capacity of chief chemist and metallurgical superintendent . . . Received a temporary appointment as Curator, Department of Chemistry, University of California, Berkeley, in 1930 . . . Affiliated with Abbot A. Hanks, Inc., San Francisco, in 1932, he was named chemist and metallurgist . . . Also from 1934-41 was instructor of metallurgy, Adult Division, San Francisco Public Schools . . . Was appointed metallurgist, Mare Island Naval Shipyard in 1941.

J. A. Blastic

A native of Ohio, Mr. Blastic was born in Cleveland . . . Attended high school in Czechoslovakia and studied technical engineering at University of Prague, Prague, Czechoslovakia . . . Served his apprenticeship at the Henry Ford Trade School, Edison Institute of Technology, Greenfield Village, Mich. . . . From 1929-41 was connected with Ford Motor Co., Detroit, in the chemical and metallurgical department . . . Advanced to the position of technical assistant during that period of time . . . Joined the metallurgical department, Detroit Diesel Engine Div., General Motors Corp., Detroit, in 1941 . . . Was on special assignment and later was named metallurgical contact man within the corporation . . . During the war he was made supervisor of General Motors' welding training program, welding and salvage of castings for the armed forces . . . At present is project metallurgist . . . Is serving his second year as chairman on General Motors' Cast Iron Welding Sub-Committee, Joining Processes Sub-Committee . . . Member of American Institute in Prague, American Welding Society and A. F. A. . . . Assisted in writing the paper *"Cast Iron Repair Welding Metallurgical Aspects"* with Messrs. Griffin and Diebold.

C. R. Jelm

Born in Akron, Ohio, June 4, 1921 . . . Attended and graduated from Massachusetts Institute of Technology, Cambridge, Mass. (1942) . . . Became affiliated with Watertown Arsenal, Watertown, Mass., following graduation . . . Was named associate metallurgist . . . Two years later (1944) was appointed metallurgical engineer, Thompson Aircraft Products Co., Euclid, Ohio . . . Is co-author (with S. A. Herres) of the paper appearing in this magazine *"Steel Castings and Weldments Residual Stress Relief"* . . . Member of ASM.

S. A. Herres

S. A. Herres, co-author with C. R. Jelm of the paper *"Steel Castings and Weldments Residual Stress Relief,"* was born in Denver, Colo. . . . Obtained his metallurgical engineering degree from Colorado School of Mines, Golden, Colo., in 1939 . . . Was appointed assistant to metallurgist, Mack Mfg. Co., New Brunswick, N. J. (1939) . . . From 1941-42 was research associate, Battelle Memorial Institute, Columbus, Ohio . . . During this year, the author was busily engaged in performing one of the first tasks necessary for the publishing of the HANDBOOK OF CUPOLA OPERATION—compiling abstracts dealing with cupola operation . . . A total of 495 abstracts were made by Mr. Herres and supplied to members of the respective subcommittees . . . In 1942 entered the armed forces as a lieutenant and was assigned to the Watertown Arsenal, Watertown, Mass. . . . As a member of the Ordnance Department he was placed in charge of welding research . . . At present is a captain stationed at the above arsenal . . . Has written technical papers dealing with welding of alloy steels and weldability of high strength constructural steels . . . A member of ASM, AWS and American Foundrymen's Association.

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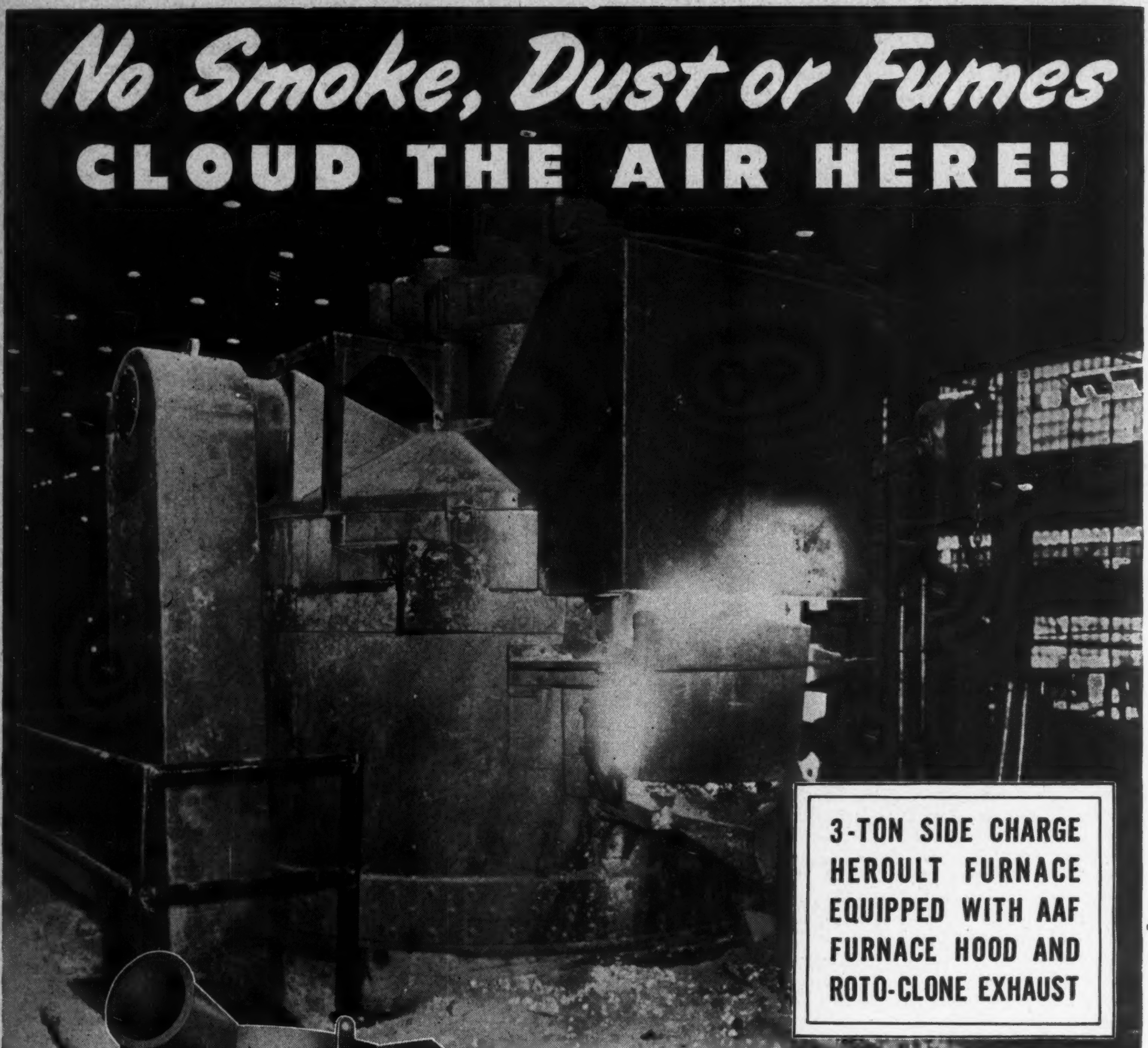

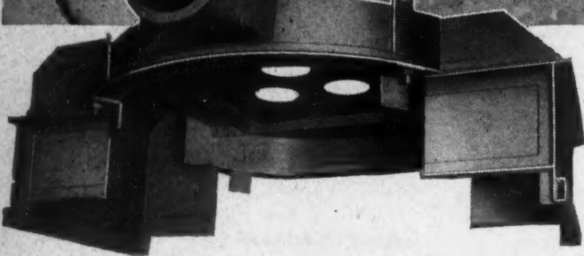

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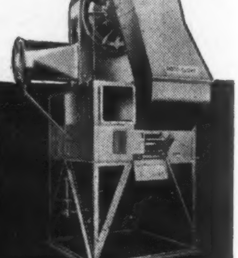


THE RIGHT TO SERVE

A.F.A.'s Third Annual Chapter Chairman Conference and the Annual Meeting of its Board of Directors were more than manifestations of the earnest interest of foundrymen in the advancement of their industry and of the action-power and value of organized cooperation. These meetings vividly re-emphasized that the programs and activities of the American Foundrymen's Association are clear perceptions of the needs and thinking of the foundry industry, and capably designed to assist the industry to place itself upon a sound foundation.

All producers of castings are well aware that the post-war period calls not only for fast-paced mechanization and modernization to gear the industry's productive powers to the expanded needs of the times, but also for full application of the great advances in the science of casting made in the war years.

The comprehensive plans for the A.F.A. Technical Development Program, outlined at the Chapter Chairman Conference, recognize the necessity of a quick, industry-wide adoption, in this competitive age, of the tested, advanced techniques developed under the urgencies of wartime and the importance of intensified, broadened research to extend those advances continuously. Thorough technical committee organization will result in added efficiency of program performance.

An outstanding feature of the Technical Development Program is the educational work it embraces, an activity designed to encourage and systematize apprentice training and to heighten the interest of high school, vocational and engineering school students and graduates in the foundry as a career. The educational activities of A.F.A., to be implemented by its chapters, reflect, in turn, the importance foundrymen attach to thoroughgoing educational efforts, and evidence that foundrymen everywhere are aware that the foundries and the schools of the Nation must serve as the training ground if the foundry industry is to develop an adequate and constant supply of intelligent, efficient manpower.

The industry's awareness of the importance of educational work is equally as great, the Chapter Chairman Conference indicated, as its appreciation of the critical need of improved working conditions, modernization, mechanization and better housekeeping.

Tomorrow's demands and competition will call, unquestionably, for the best in us; and A.F.A. is completely prepared to assist foundrymen to give their best, today and tomorrow. With all its activities well organized, and tailor-made to the needs of the industry, A.F.A. continues to earn its right to serve by giving full and forward-looking service.

Max Kuniansky

Max Kuniansky, *Vice-President,*
American Foundrymen's Association

The author of this editorial, Max Kuniansky, is vice-president and general manager, Lynchburg Foundry Co., Lynchburg, Va. Currently serving as Vice-President of the American Foundrymen's Association, he has also held the position of A.F.A. National Director and has been active on such national groups as the Executive Committee, Gray Iron Division; Subcommittee on Engineering Properties Symposium; Committee on High Temperature Properties of Cast Iron; Advisory Committee, Technical Development Program; and, as Vice-Chairman of the gray iron group, U. S. Ordnance Committee. He has been named to the newly-created Advisory Group of the Gray Iron Division. Mr. Kuniansky has lectured before many of the Association's chapters, and has prepared various gray iron papers for A.F.A. conventions.

NON-FERROUS ALLOY CASTINGS

GAS ELIMINATION

George Dalbey
Mare Island Naval Shipyard
Mare Island, Calif.

GAS IN METALS is a subject which usually brings on a lively debate in any gathering of foundrymen. The following observations and preliminary experiments are offered as more fuel to the debate, and as a partial answer to a furnaceman's statement that in melting metal, and in spite of the utmost care, an occasional heat of metal will be gassed, otherwise known as a "wild heat." What, then, can be done to eliminate the gas and how much gas can be eliminated?

It is the belief among foundry furnacemen that commercially gas-free metal can be produced in the foundry by melting metal under a neutral or slightly oxidizing atmosphere.

Men operating the oil-fired Schwartz furnace in this foundry endeavor to melt the metal rapidly, under a slightly oxidizing flame, at the same time avoiding an excessively high temperature. The metal is removed from the furnace as soon as possible after the proper temperature has been reached. This procedure has been largely successful in producing a metal low in gas.

It is believed by many that gas will escape from molten metal under proper conditions. Professor Cecil Desch, of Sheffield University, England, made the following statements regarding his observations on the gas content of liquid metal: "Unlike other liquids, molten metals dissolve more gas as the temperature rises, so that the more the metal or the alloy is overheated before casting, the more gas will be dissolved; and so such solutions easily remain supersaturated. An overheated metal usually will contain more gas at the moment of pouring than one that has been heated only to proper pouring temperature."

Gas Given Off

He also states: "In some cases the gas would be given off on cooling, before the casting temperature was reached, and it was only in the case of rapid cooling that one would expect to get any supersaturated solution."

In the melting and casting of aluminum bronze, Professor H. C. H. Carpenter, of Imperial College of Science and Technology, England, made the following statement: "After the metal had been poured and cleared of its dross, it would be allowed to remain in the crucible as long as possible before pouring. With the fall of temperature the solubility of gas diminishes. Corresponding to this there is a liberation of dissolved gas."

Gas in non-ferrous alloys may be eliminated in large part by holding the gas-contaminated metal for a sufficient period at a temperature above its melting point in an atmosphere relatively free of the contaminating gas. Experiments also indicate that a drop in temperature during the holding period is not necessary to secure elimination of a large part of the gas.

Oil-Fired Schwartz Furnace Observations. Early in the summer of 1942 a large, covered, well insulated thermal ladle holding 1000 lb. of metal was put into use at the "Yard" foundry. Experiments were made in removing all of the metal from the Schwartz furnace at one time, at the same time keeping the metal sufficiently hot so that all would pour.

It was observed on occasional heats that the risers on the first molds poured would mushroom, and that the risers on the last molds would have a good shrink. This indicated that the gas probably was escaping from the metal during the 10 to 15 min. required to pour the ladle of metal.

On some occasional gassed heats another phenomenon was observed. When light castings and heavy castings were poured at the same time, the risers on the light castings would shrink, and the risers on the large castings would mushroom. This indicated that a mass effect, on the metal solidifying rate, is a factor in the liberation of gas.

Electric Furnace Observations. When melting a copper-nickel alloy in an indirect-arc, rocking electric furnace, and making no effort to control the gas content since the metal was to be remelted, the following observations were made:

Power was turned off when the metal was at the proper temperature. The first ladle of metal tapped

NOTE: The opinions or assertions contained herein are those of the author and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large. Presented at a Brass and Bronze Session of the Fiftieth Annual Meeting, American Foundrymen's Association at Cleveland May 8, 1946.

was wild, with violent effervescence, and the ingots into which the metal was poured mushroomed badly. The second ladle, with only a slight effervescence, produced ingots with only a slight mushrooming.

Shrinkage

The third ladle was quiet and produced ingots with a good shrink. This would indicate that the gas was escaping during the time that the metal was held in the furnace. The total time from the moment the power was turned off to the finish of pouring was about 10 min.

In taking samples of monel metal from the electric furnaces the following observations were made. When two small ladles of the same size were used simultaneously to dip metal from the furnace, the metal in the ladle made of graphite would solidify rapidly, forming a dense test button with a good shrink.

The metal in the well-dried ladle made of fire clay would solidify more slowly, forming a test button with little if any shrink, and often would mushroom. From this it may be concluded that a metal containing some gas will produce a satisfactory casting if solidification is sufficiently rapid.

Test Casting. The following castings were adopted as the standard test castings:

The test casting called the large test casting was a truncated cone 6 in. high of 3¾-in. diameter at the top and 2-in. diameter at the bottom. The cone had a poured open top and was covered with dry charcoal to promote feeding. This arrangement should produce sound metal in the bottom half of the casting if the metal is gas free. A small, flat bar casting, 2x1x½ in., poured vertically and called the small test casting was also tested.

Gassing Metal. The metal was melted in a small, gas-fired crucible furnace, the atmosphere of which could readily be made oxidizing or reducing. It was possible to produce gassed metal a large part of the time by melting and overheating in a reducing atmosphere. This method was somewhat uncertain because sometimes the metal, when poured into the large test casting, would not mushroom.

In order to produce badly gassed metal consistently, the following procedure was adopted. When the metal was melted a slightly damp lump of fire clay was floated on top of the liquid metal for about 3 min., by which time the metal had absorbed sufficient gas so that it would mushroom badly when poured into the large test casting.

Test Procedure. A heat of hydraulic bronze taken at random from the Schwartz furnace was tested for gas elimination, using the difference in specific gravity as a measure of the gas eliminated. Metal was taken from the metal stream coming from furnace, entering thermal ladle.

Large test casting *A* was poured at 2200° F. The shrink on test casting was normal. The fracture of this casting was slightly spongy and had many scattered golden spots, and the specific gravity was 8.71.

Large test casting *B* was poured at 2090° F. after holding metal in the ladle for 12 min. The shrink on test casting was normal. The fracture was slightly spongy with some scattered golden spots, and the specific gravity was 8.79.

Regular castings were poured 5 min. after the metal entered the ladle. None of the risers of the regular castings mushroomed. The metal made satisfactory castings.

Several 35-lb. heats of metal were melted in the gas-fired, laboratory crucible furnace, and gassed or not as the occasion demanded. The first test casting was poured. The remainder of the metal was treated and the second and third castings poured. The castings then were sectioned and examined for differences.

Samples

Cross sections and fractures were taken from the similar locations in each set of castings. The etching solution used on the specimens was ammonium persulphate. For complete details, see the accompanying photographs, photomicrographs and descriptions of tests.

Shrinkage Porosity Pattern Due to Lack of Feeding in Hydraulic Bronze Casting. To observe the difference in properties between poorly-fed and well-fed castings, a 35-lb. heat of hydraulic bronze was melted in a gas-fired, laboratory crucible furnace, under a slightly oxidizing flame. The temperature of the metal in the furnace did not exceed 2200° F.: pouring temperature, 2100° F.

Two truncated cone test castings (Figs. 1 to 8) were poured out of the same crucible of metal, and with as short a lapse of time as possible between pourings. To prevent feeding, the top of casting (Fig. 1) was frozen as soon as possible by pouring water on top of the casting.

Feeding

To promote feeding, the top of casting (Fig. 2) was covered with dry charcoal as soon as possible.

To observe the porosity pattern, the castings were split vertically. The specific gravity was determined on a half cross section taken 2 in. from the bottom. The cross section was broken so that the fracture could be examined. Specific gravities of the half cross sections shown in Figs. 1 and 2 were 8.82 and 8.88, respectively.

Gas Porosity Pattern. The gas porosity pattern generally produced in hydraulic bronze is similar to that shown in Figs. 9 and 10. The photograph (Fig. 9) is of a cross section of a riser just above the casting. The metal from which this casting was poured was melted in an oil-fired Schwartz furnace, and evidently was gassed in melting, because all of the risers on the castings poured from this heat of metal mushroomed.

Similar castings poured from another heat of metal did not have mushroomed risers. The molds were made from the same sand, by the same molder. The gas porosity pattern often produced in manganese bronze is shown in Figs. 11 and 12.

Figure 11 shows a cross section of a riser just above the casting. The metal in this casting was melted in an oil-fired Schwartz furnace. The metal was gassed accidentally by pouring into a newly lined ladle which was not thoroughly dry. The risers on castings poured from the same heat of metal, but from a different ladle, did not mushroom.

A marked difference in gas porosity patterns produced in the different alloys is evident.

Gas Elimination in Aluminum Bronze. To determine the effect of time and temperature on the elimination of gas from molten aluminum bronze, the following experiment (Figs. 13 to 16) was undertaken.

A 35-lb. heat of aluminum bronze

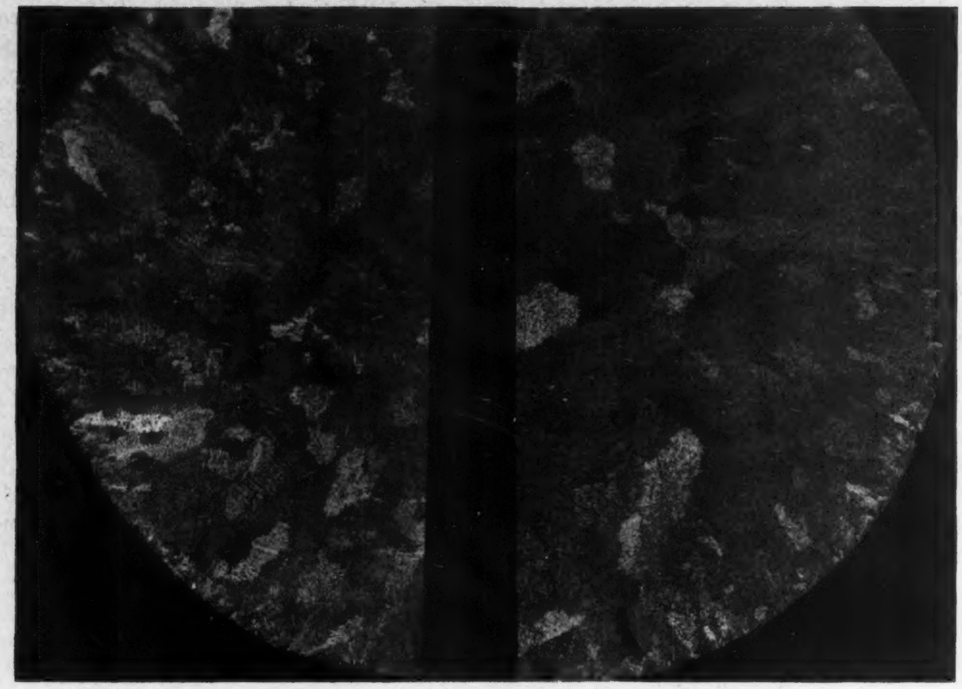


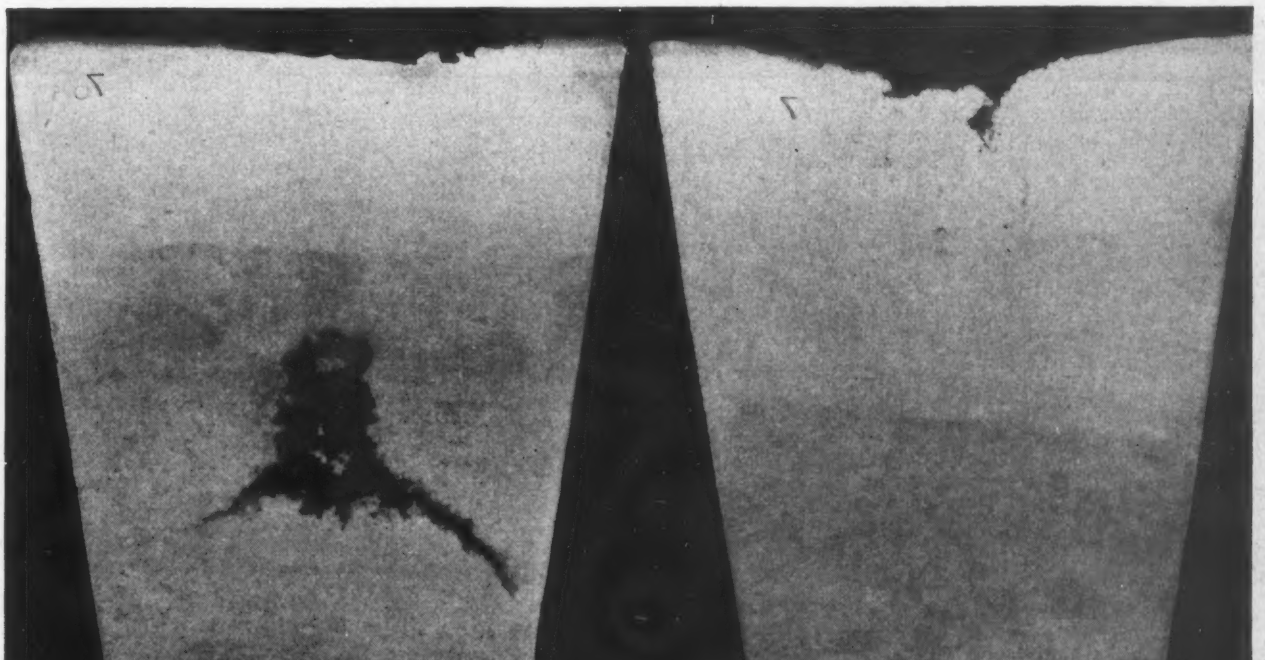
Fig. 1 (left)—A half cross section of the poorly fed casting, showing considerable fine porosity in center. Strongly etched with ammonium persulphate. About 2X.
Fig. 2 (right)—A half cross section of the well fed casting, showing little if any porosity. Strongly etched with ammonium persulphate. About 2X.

Fig. 3—An enlargement of the half cross section of the poorly fed casting (Fig. 1) showing considerable porosity. Strongly etched with ammonium persulphate. About 25X.

Fig. 4—An enlargement of the half cross section of the well fed casting (Fig. 2), showing little if any porosity. Strongly etched with ammonium persulphate. About 25X.

Fig. 5 (left)—A fracture of the half cross section of the poorly fed casting (Fig. 1). The fracture was spongy and had a color range from blue-gray through golden to dark brown. About 1¼X. Fig. 6 (right)—A fracture of the half cross section of the well fed casting (Fig. 2). The fracture was solid and dense and was blue-gray in color. About 1¼X.

Fig. 7 (left)—A vertical section of the poorly fed casting, showing gross porosity. Slightly etched with ammonium persulphate. About ⅞X. Fig. 8 (right)—A vertical section of the well fed casting, showing lack of gross porosity. Slightly etched with ammonium persulphate. About ⅞X.



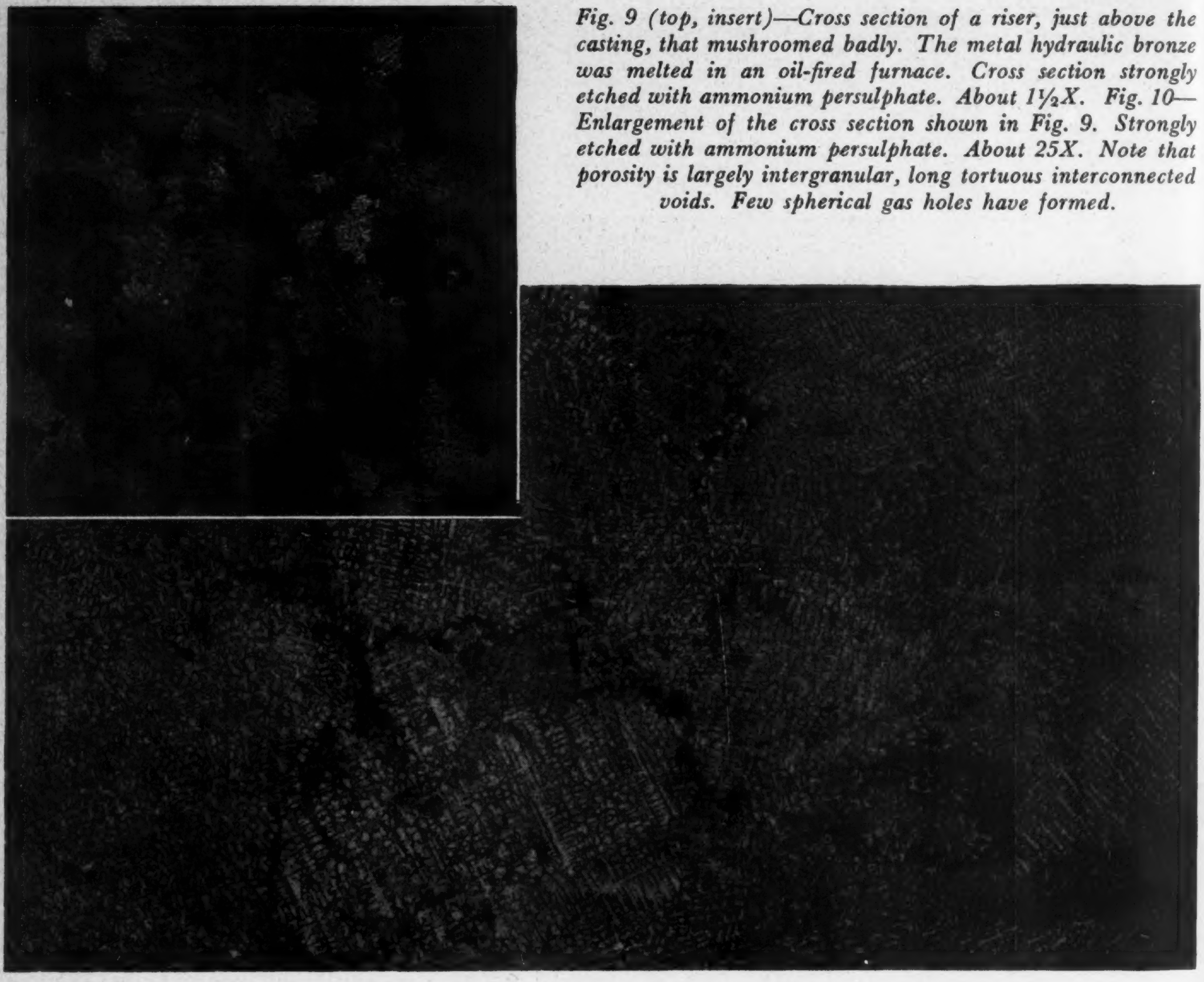
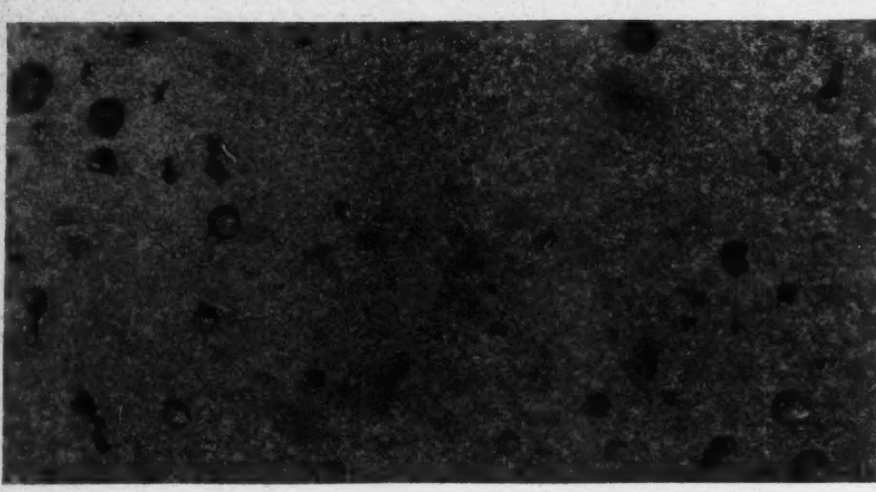


Fig. 9 (top, insert)—Cross section of a riser, just above the casting, that mushroomed badly. The metal hydraulic bronze was melted in an oil-fired furnace. Cross section strongly etched with ammonium persulphate. About 1½X. Fig. 10—Enlargement of the cross section shown in Fig. 9. Strongly etched with ammonium persulphate. About 25X. Note that porosity is largely intergranular, long tortuous interconnected voids. Few spherical gas holes have formed.



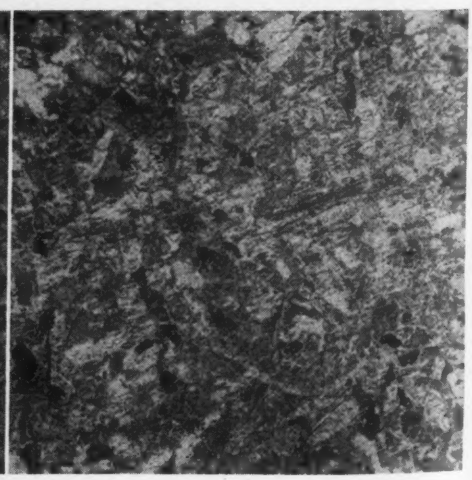


Fig. 11 (left)—Cross section of a riser that mushroomed badly. The metal manganese bronze melted in an oil-fired furnace. Cross section strongly etched with ammonium persulphate. About 1½X. Metal accidentally gassed by pouring into a new ladle that had not been thoroughly dried. Fig. 12 (right)—Enlargement of cross section shown in Fig. 11. Strongly etched with ammonium persulphate. About 25X. Note that porosity is largely spherical with little if any tortuous interconnected voids.

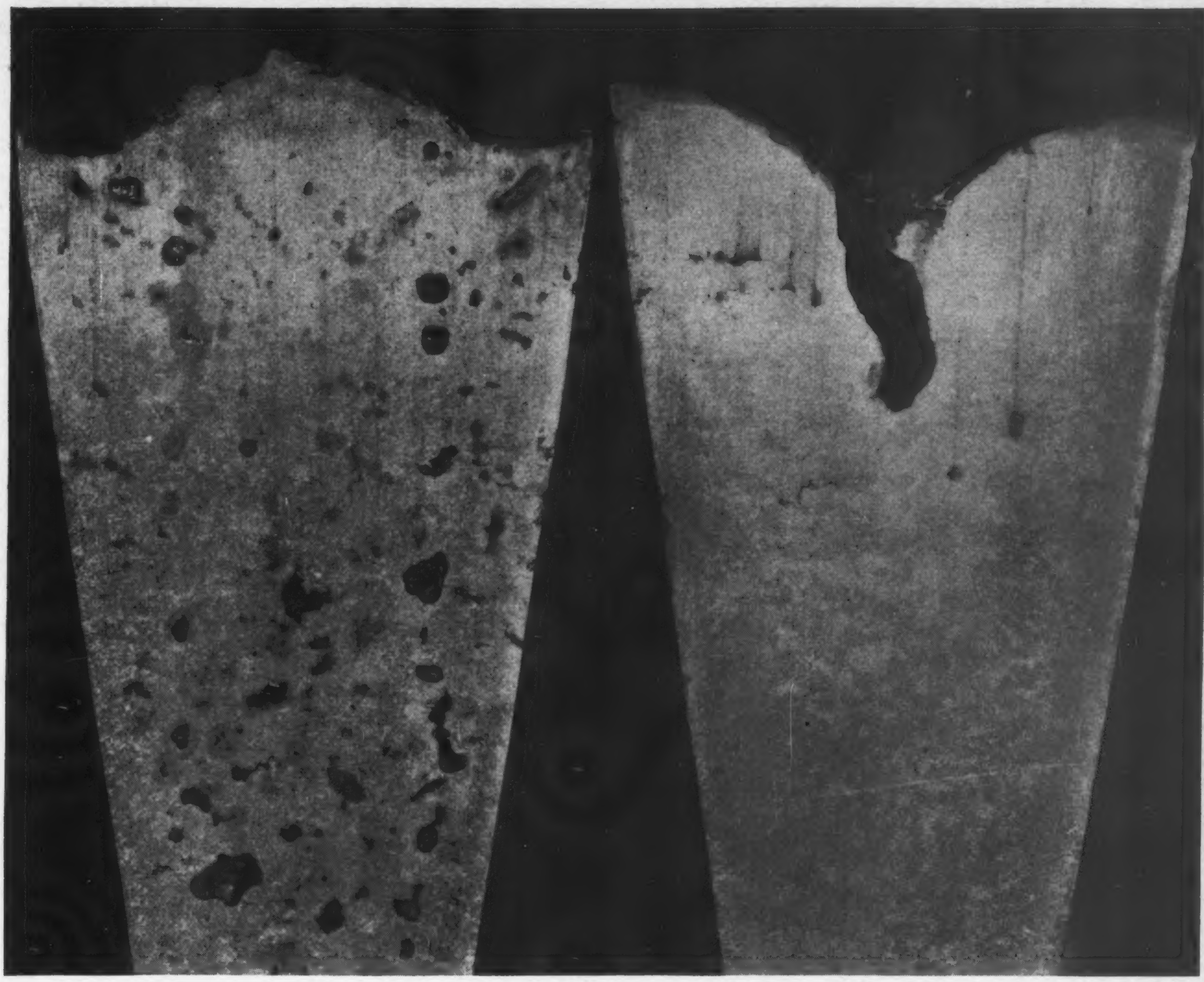


Fig. 13 (left)—Vertical section of the test casting poured at 2200° F. immediately after gassing. Lightly etched in ammonium persulphate. About 7/8X. Fig. 14 (right)— Vertical section of the third test casting poured at 1980° F. Lightly etched in ammonium persulphate. About 7/8X. Note marked reduction in porosity.

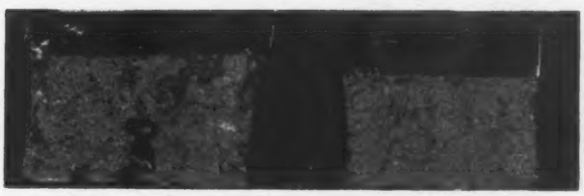


Fig. 15 (left)—Fracture of the half cross section of the badly gassed casting. Fracture was coarse and spongy. Interiors of the holes were a bright yellow color. About 1¼X. Fig. 16 (right)—Fracture of the half cross section of the third casting poured at 1980° F. Fracture had an even color distribution and showed little if any gas porosity. About 1¼X.

Fig. 17 (left)—Vertical section of the first test casting poured at 2360° F. immediately after gassing. Lightly etched with ammonium persulphate. About 7/8X. Fig. 18 (right)—Vertical section of the third test casting poured at 2050° F. Lightly etched with ammonium persulphate. About 7/8X. Note marked reduction in porosity.

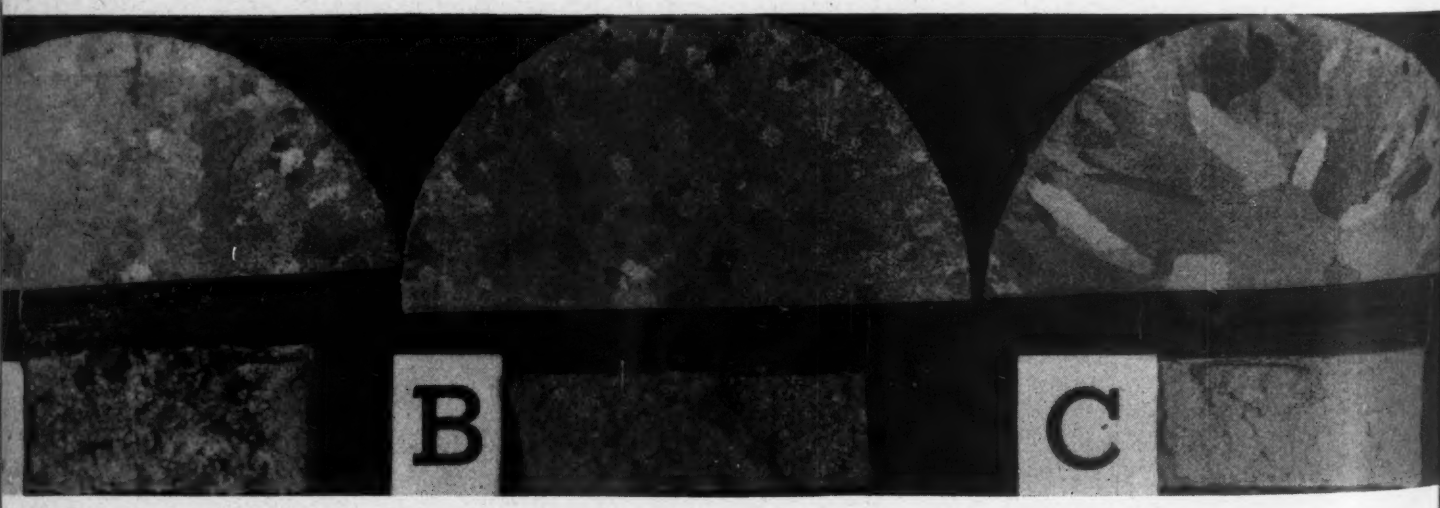


Fig. 19A—Half cross section and fracture from casting (Fig. 17). The half section shows considerable porosity. Fracture was coarse, spongy, and badly discolored. Specific gravity—8.13.

Fig. 19B—Half cross section and fracture from casting (no photograph of vertical section). Half section shows considerable porosity. Fracture was coarse and discolored. Specific gravity—8.44.

Fig. 19C—Half cross section and fracture from casting (Fig. 18). The half section showed little if any porosity. Fracture was a fine blue-gray. About 1¼X. Specific gravity—8.82.

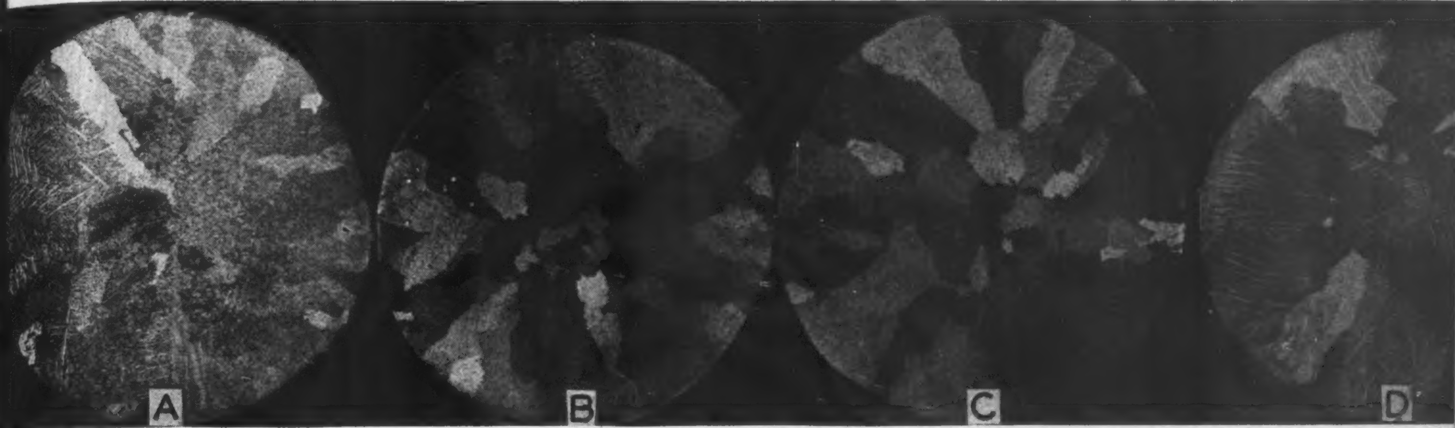


Fig. 20A-B-C-D—Cross sections of test castings. Strongly etched with ammonium persulphate. About 1X. Note gradual diminution of porosity from A to D.

Fig. 21—Enlargement of the cross section of first test cone (Fig. 20-A) which mushroomed badly. Strongly etched with ammonium persulphate. About 25X. Porosity is distributed within the grains and at grain boundaries. All the dark areas are voids.

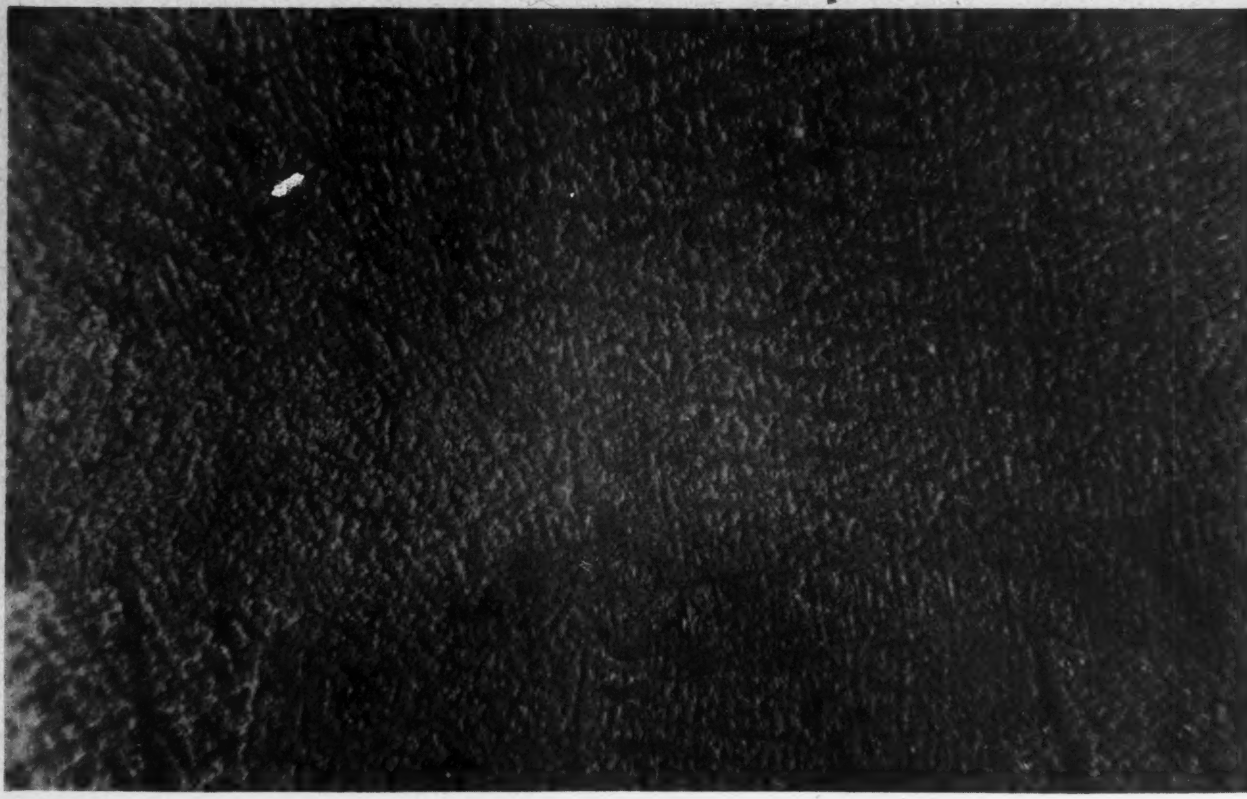


Fig. 22—Enlargement of the cross section of the fourth test cone (Fig. 20D) which had a good shrink. Strongly etched with ammonium persulphate. About 25X. Marked reduction in porosity comparing Fig. 20, A and D.

was melted in a gas-fired, laboratory crucible furnace. The metal was brought to a temperature of 2230° F. and gassed by floating a lump of damp clay on the surface of the metal for 3 min.

The first test cone (Fig. 13) was poured immediately after gassing. Pouring temperature was 2200° F. The casting mushroomed badly. The remainder of the metal was returned to the furnace and held for 5 min. with the furnace fuel turned off.

Effect of Furnace Cooling

The second test cone was poured at 2100° F. The casting mushroomed badly. No photographs were taken of this casting because it appeared similar to that shown in Fig. 13. The remainder of the metal was returned to the furnace and held for 6 min. with the furnace fuel turned off.

The third test cone (Fig. 14) was poured at 1980° F. after a total holding time of 11 min. The casting had a normal shrink.

In order to observe the porosity the castings were split vertically. The specific gravity was determined on a half cross section taken 2 in. from bottom of the casting. The half cross section was broken so that the fracture could be examined. Specific gravity of the test casting shown in Fig. 13 was 6.91, and that of casting shown in Fig. 14, 7.61.

A large part of the gas evidently will escape from molten aluminum bronze if the time is sufficient, and with the possible assistance of a drop in temperature.

Gas Elimination in Hydraulic Bronze. To determine the effect of time and temperature on the elimination of gas from molten hydraulic bronze, the following experiment was undertaken.

A 35-lb. heat of hydraulic bronze was melted in a gas-fired, laboratory crucible furnace. The metal was brought to a temperature of 2400° F. and gassed by floating a lump of damp clay on the surface of the metal for 3 min.

The first test cone (Fig. 17) was poured at a temperature of 2360° F. immediately after gassing. The casting mushroomed badly. The balance of the metal was returned to the furnace and held 4 min. with the furnace fuel turned off.

The second test cone (no photographs) was poured at a temperature of 2240° F. The casting mushroomed less than that shown in Fig. 17. The remainder of the metal was returned to the furnace and held for 10 min. with the furnace fuel turned off.

The third test cone (Fig. 18) was poured at a temperature of 2050° F. after a total holding time of 14 min. The casting had a normal shrink.

Observations

To observe the porosity the castings were split vertically. The specific gravity was determined on a half cross section taken 2 in. from the bottom of the casting. The half cross section was broken so that the fracture could be examined. Specific gravities of half cross sections

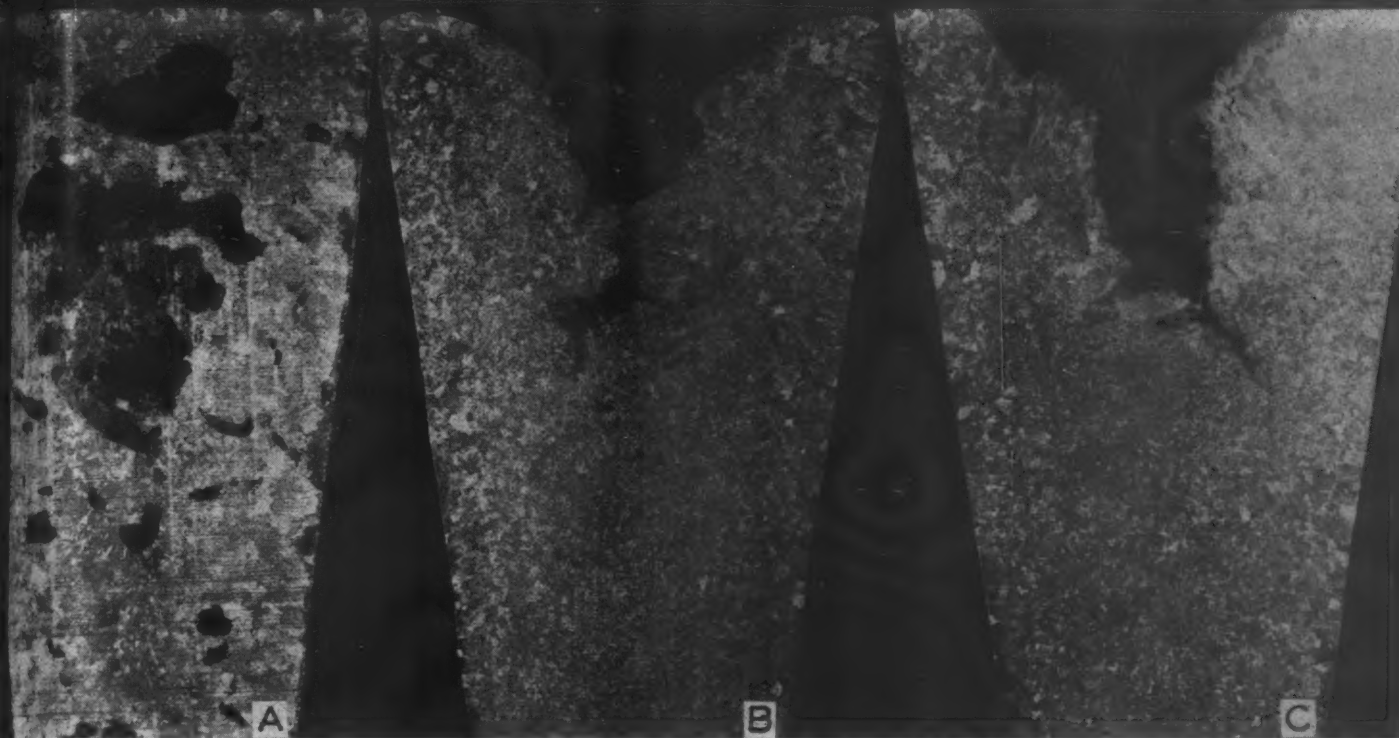


Fig. 23A—Vertical section of the first test casting poured at 2775° F. Strongly etched with ammonium persulphate. About ⅞X. Note gross porosity and mushrooming.
Fig. 23B—Vertical section of the second test casting poured at 2795° F. Strongly etched with ammonium persulphate. About ⅞X. Note fine scattered porosity and the shrinkage.
Fig. 23C—Vertical section of the third test casting poured at 2790° F. Strongly etched with ammonium persulphate. About ⅞X. Note absence of visible porosity. Markedly more shrinkage than in Fig. 23B.

of the three test cones (Fig. 19, left to right) were 8.13, 8.44 and 8.82.

A large part of the gas evidently will escape from molten hydraulic bronze if the time is sufficient, and with assistance of a temperature drop.

Gas Elimination in Monel Metal (various pouring temperatures). To determine the effect of time and temperature on the elimination of gas from molten monel metal, the following experiment was undertaken.

A 200-lb. heat of monel metal pig was melted in a 350-lb. capacity indirect-arc, rocking electric furnace. The metal was brought to a temperature of 3050° F. The first test cone (Fig. 20-A) was poured immediately at a temperature of 3000° F. The casting mushroomed badly. The remainder of the metal was held in the furnace for 5 min. with

Fig. 24A—Half cross section taken 2 in. from bottom of first test casting (Fig. 23A) poured at 2850° F. Strongly etched with ammonium persulphate. About 1¼X. Note the gross porosity and almost complete absence of fine porosity.
Fig. 24B—Half cross section taken 2 in. from bottom of second test casting (Fig. 23B) poured at 2775° F. Strongly etched with ammonium persulphate. About 1¼X. Note fine porosity and some reduction of gross porosity.
Fig. 24C—Half cross section taken 2 in. from bottom of third test casting (Fig. 23C) poured at 2795° F. Strongly etched with ammonium persulphate. About 1¼X. No gross porosity and only a small amount of fine porosity concentrated in central area of casting.

Fig. 25A—Enlargement of half cross section (Fig. 24A). About 16X. Considerable gross porosity. The dark dendritic patterns are not voids.

Fig. 25B—Enlargement of the half cross section (Fig. 24B). About 16X. Considerable gross porosity but finer than that shown in Fig. 24A. Voids are the elongated tortuous dark areas.

Fig. 25C—Enlargement of the half cross section (Fig. 24C). About 16X. Porosity is of the fine interdendritic tortuous type. Voids are the fine thin elongated tortuous dark areas.

all the furnace power turned off.

A second test cone (Fig. 20-B) was poured. The casting mushroomed less than the casting shown in Fig. 20-A. The remainder of the metal was held in the furnace for an additional 5 min. with power turned off.

A third test cone (Fig. 20-C) was poured. The casting mushroomed less than that of Fig. 20-B. The remainder of the metal was held in the furnace for an additional 5 min. with power turned off.

A fourth test cone (Fig. 20-D) was poured at a temperature of 2710° F. The casting had a good shrink.

Temperature Control

Total holding time was 15 min. The total drop in pouring temperature was 290° F. The optical pyrometer was used in determinations.

Cross sections were taken 2 in. from the bottom of each casting and etched in ammonium persulphate. Specific gravities of cross sections A and D of Fig. 20 are 8.04 and 8.69.

Figures 21 and 22 are enlargements of A and D sections of Fig. 20.

A large part of the gas evidently will escape from molten monel metal if the time is sufficient, and with the possible assistance of a drop in temperature.

Gas Elimination in Monel Metal (constant temperature). To determine the effect of time, while holding the temperature constant, on the elimination of gas from molten monel metal the following experiment was undertaken.

A 35-lb. heat of monel metal pig was melted in a magnesia crucible in an electric induction furnace. The metal was brought to a temperature of 2850° F. and gassed by floating a lump of damp clay on the surface of the metal for 15 min. Magnesium as a deoxidizer was added at rate of 1½ oz. per 100 lb. of metal.

The first test cone (Fig. 23-A) was poured immediately after adding the magnesium at a temperature of 2775° F. The casting mushroomed badly. The top of the casting was rough and drossy. The balance of the metal was held in the furnace for 10 min. with just sufficient power on to maintain the temperature.

A second test cone (Fig. 23-B) was poured at a temperature of 2795° F. The casting had a marked

Fig. 26A—Fractured half section and adjacent polished and etched section. About 4X. Marked degree of porosity. Fig. 26B—Fracture of the small casting and adjacent polished and etched section. About 4X. Much less porosity in the small casting.

shrink. The top of the casting was free from dross. The balance of the metal was held in the furnace for an additional 10 min. with just enough power on to maintain the temperature.

The third test cone (Fig. 23-C) was poured at a temperature of 2790° F. The casting had a marked shrink, larger than that shown in Fig. 23-B. The top of the casting was free from dross.

Total holding time was 20 min. There was a temperature increase of 20° F. An optical pyrometer was used to determine temperatures.

To observe the porosity the castings were split vertically. Specific gravities determined on half cross sections taken 2 in. from bottom of casting (Fig. 24-A, B, C) were 8.273, 8.715 and 8.774, respectively. Figure 25 shows enlargements of the sections shown in Fig. 24.

A large part of the gas evidently will escape from molten monel metal if the time is sufficient at a constant temperature, and with the possible assistance of the stirring action in the furnace.

Mass Effect on Gas Elimination in Aluminum Bronze. To determine the effect of the solidifying rate on the elimination of gas from molten aluminum bronze, the following experiment was undertaken.

A 35-lb. heat of aluminum bronze was melted in a gas-fired, laboratory crucible furnace. The metal was brought to a temperature of 2200° F. and gassed by floating a lump of damp clay on the surface of the metal for 3 min. A mold was poured at a temperature of 2120° F., making the large truncated cone and the small flat bar, 2x1x½ in. (Fig. 26-A, B). The cone solidified slowly and the small bar solidified rapidly. The cone (Fig. 26-A) mushroomed badly. The small bar (Fig. 26-B) had a shrink in the top.

Porosity Observed

To observe the porosity in the castings, the cone was split and a half cross section was taken 2 in. from the bottom of the casting. The half section was broken, so that the fracture could be examined. A section adjacent to the fracture was polished and etched. The specific gravity was determined on the half cross section.

The small casting was broken transversely at about the center. A section adjacent to the fracture was polished and etched. The specific gravity was determined on the bottom half of the casting, that of the cone (Fig. 26-A) being 7.10, and that of the small casting (Fig. 26-B) 7.60.

With a metal of a given gas content more porosity can be expected in heavy castings than in light castings.

Mass Effect on Gas Elimination in Hydraulic Bronze. To determine the effect of the solidifying rate on the gas elimination from molten hydraulic bronze, the following experiment was undertaken. A 35-lb. heat of hydraulic bronze was melted in a gas-fired laboratory crucible furnace.

The metal was brought to a temperature of 2450° F. and gassed by floating a lump of damp clay on surface of molten metal for 45 sec.

A mold was poured at a temperature of 2300° F., making the large truncated cone (Fig. 27-A), and the small flat bar (Fig. 27-B), 2x1x½ in. The cone solidified slowly and the small bar solidified rapidly.

The remainder of the molten metal in the crucible was held for 3½ min., until the temperature dropped to 2000° F., at which time

the same kind of a mold was poured, making a large truncated cone (Fig. 27-D), and the small flat bar (Fig. 27-C).

To observe the porosity in the castings the cones were split and half cross sections were taken 2 in. from the bottom. The half sections were broken, so that the fractures could be examined. Sections adjacent to the fractures were polished and etched. The specific gravity was determined on the half cross sections.

Castings Broken Transversely

The small castings were broken transversely, at about the center. Sections adjacent to the fractures were polished and etched. Specific gravities were determined on the bottom halves of the castings, being 8.35, 8.60, 8.75 and 8.51, respectively, for the sections shown in Fig. 27-A-B-C-D.

The large cone (Fig. 27-A) mushroomed badly. The fracture was spongy and badly discolored. The polished section had considerable porosity.

The small bar casting (Fig. 27-B) had a slight shrink. The fracture was spongy and discolored, but less so than the fracture on section A. The polished section had much less porosity than the polished section A.

The large cone (Fig. 27-D) had a slight shrink. The fracture was slightly spongy and discolored, but less so than section A. The polished section had considerably less porosity than the polished section of section A.

The small bar casting (Fig. 27-C) had a good shrink. The fracture was slightly spongy, much less so than the fracture on section B. The polished section had much less porosity than the polished sections B and D.

Indications are that a large part of the gas can be eliminated from metals by holding the gas-contaminated metal for a sufficient time above its melting point in an atmosphere relatively free of the contaminating gas.

It is not necessary to have a drop in temperature during the time lapse to eliminate a large part of the gas.

A not unusual occurrence in a foundry is to pour a heavy casting and a light casting from the same ladle of metal, and to have the risers on the heavy casting mushroom and risers on the light casting shrink.

Melter vs. Molder

This brings forth a dogmatic statement from the furnaceman: "The molds are too wet, rammed too hard, or sand too fine." The molder retorts with: "The metal is burned and full of gas."

A possible explanation is that the small casting solidified rapidly enough to hold a large portion of the gas in solution so that no porosity resulted. The heavy casting solidified slowly enough to allow the gas to migrate and concentrate in the last metal to solidify, with resulting porosity and mushrooming of risers. The above mentioned mold conditions could also cause the metal to mushroom.

Fig. 27A—Fracture and adjacent polished sections from truncated cone test casting. Fracture was badly discolored.
Fig. 27B—Fracture and adjacent polished section from small flat bar casting. Fracture was less discolored than cone casting (Fig. 27A).
Fig 27C—Fracture and adjacent polished section from small flat bar casting. Fracture only slightly discolored, less than that of the cone casting (Fig. 27D).
Fig. 27D—Fracture and adjacent polished section from truncated cone test casting. Fracture was less discolored than that shown in Fig. 27A.

Complete Program and Paper Group Formation

ORGANIZATION of the Program and Papers Committee, Gray Iron Division, under chairmanship of Division Vice-Chairman R. J. Allen, metallurgical engineer, Worthington Pump & Machinery Corp., Harrison, N. J., has been completed in accordance with the plan for divisional committee modification recently adopted by the A.F.A. Board of Directors*.

Composition of the committee is three officers and four additional members, the limitation in size placed upon division committees in the interests of more efficient performance.

Vice-Chairman of the committee is R. G. McElwee, manager, Foundry Alloy Div., Vanadium Corp. of America, Detroit; and Secretary is T. D. Parker, metallurgical engineer, General Electric Co., West Lynn, Mass.

Other members are: K. H. Priestley, president, Vassar Electroloy Products, Inc., Vassar, Mich.; W. W. Levi, metallurgist, Lynchburg Foundry Co., Radford, Va.; A. E. Schuh, director of research, U. S. Pipe & Foundry Co., Burlington, N. J.; and J. S. Vanick, metallurgist, International Nickel Co., New York.

*See page 48, in this issue.

ACCELERATED TRAINING

American industry can not afford to lose the training gains which were made during the war period. In postwar operations, speedy and adequate training of workers will be an important factor in balancing the plant budget.

W. J. Hebard
Personnel Director
Continental Foundry & Machine Co.
East Chicago, Ind.

MANY CHANGES have been brought about in the foundry industry because of the termination of war production. In many respects plants are coping with different problems—new headaches to replace the headaches of wartime—but with respect to the subject of this paper, training, the problems are fundamentally the same. Only the externals are changed. Today and every day the plants are confronted with training problems.

It is true that apprenticeship in the foundry suffered a real setback during the war and is now receiving the greater emphasis that it deserves. It is true, likewise, that job-training has gone in the reverse direction.

Reduction of Training

During the war it was necessary to develop rather elaborate programs, with training staffs planning for large groups of trainees and special job instructors in every department. The end of the war, bringing a decreased turnover and, in many plants, decreased production, has brought about a reduction in the size of the training job—but the essence of the job is still there and it is important.

It is at this stage of the game that industry should be most concerned. During the war, costs were of secondary importance. Production in a hurry was paramount. Today, industry is extremely cost conscious—and it needs to be. Terminations, cancellations, price ceilings and wage increases have brought it up short against *cost*. Elimination of training programs can not be allowed merely because their cost can be measured and the cost of lack of training programs can not be measured. It can not be thought for a minute that going back to familiar prewar products means no further need for training.

No doubt, many will wonder why it is thought necessary to mention such a thing because the value of adequate training has been learned and is not likely to be forgotten in a hurry. Recalling a bit of history at this point may serve to explain the concern felt.

During World War I, American industry faced the same problems as it did in World War II. The "Preparedness" drive of 1916 paralleled the "Defense" drive of 1940. The "War Production" of 1917-1918—relatively at least—matched the "War Production Drive" of 1942-1945; and encountered the same problems of training quickly the thousands of green workers brought into the expanded plants.

Much was learned about the value of good training. An organization sprang up to afford an exchange of ideas among industrial training people. To sum up the knowledge of training acquired during the war, Charles R. Allen wrote his great book, *The Instructor, the Man, and the Job,* as a sort of Bible for industrial training.

When 1940 came a few corporations, mostly large ones, had fairly adequate training staffs, but in the main, American industries, and particularly the foundry industry, were not even training conscious. Fortunately, someone remembered Allen's book, got out his four-step method of job training, dressed it up in modern clothing, and brought it out as the now famous "J.I.T."—Job Instruction Training.

Government agencies, trade associations, and individual top managements, exerted strenuous efforts, first, to make industries aware of the need for adequate training, and second, to help them learn how the job should be done. The fact that the industries of America won out in the war of production was as much a tribute to the training efforts in industry as it was to the development of new techniques and new products, but it is submitted that the race might have been shortened, the cost might have been lessened, if industry had, through the years since 1919, profited by its experiences at that time.

"J.I.T." Valuable

It is to be hoped that training tools like "J.I.T." will not be permitted to gather dust for the next 25 years, and that industry not allow itself to slip back into the slow, inefficient, and costly method of hiring people and "letting them learn" their jobs. The fact that the actual cost of improper training, or no training at all, is not set apart on the books, but is hidden in the overall figure of tonnage per man hours, should not be overlooked.

For the most part the actual training job must be done by the line

Presented at an Apprentice Training Session of the Fiftieth Annual Meeting, American Foundrymen's Association at Cleveland, May 9, 1946.

supervisor. It is not often that the conditions of a particular training project in normal peacetime activity will justify the use of special instructors in the average foundry. However, there must be someone, somewhere in the organization, whose responsibility it is to anticipate the training needs, plan the training, and assist the line supervisor in doing an adequate job of training.

Production Planning

It is unfair to lay the whole job in the lap of the foreman. How elaborate, or how simple the set-up necessary for a particular organization, will depend upon the size and the type of the organization.

The responsibility for the planning of training springs from the planning of production. To illustrate the development of a specific training program which is designed to meet the needs of production planning, an example may be made of a large organization where the procedure is somewhat as follows:

When the manufacturing department plans to establish a new production line, the training department is called in, given all the detailed information as to the specific jobs which will be required, the number of people on each job, and the starting schedule.

From this information the training department makes an analysis of the training needs, taking into account for each operation how many people are needed, how many are already available, trained or partly trained in the organization, and how many must be fully trained. Each job is then studied to determine how much training is necessary and how it is to be given.

While the size of this organization justifies an elaborate training division, the same can not be said of the average foundry. However, the same fundamental problem is present, just as it is in the training of the casual replacement in an established production line.

The same function may be performed as a part-time duty of one man; it may be the full-time duty of one man, assisted by a committee of operating supervisors, or it may require a regular staff, depending upon the size of the organization, the rate of turnover, and the frequency of change in product.

It would be a waste of time to go into detail in recounting the value and importance of properly planned training for speeding up the process of bringing employees on a new job to full production. From the author's plant might be cited the case of training crane operators in 5 days, as compared with the "let them learn" process, which previously took from 30 to 60 days.

Experience in training women as coremakers and mold finishers in a two-week program, with what can be considered remarkably fine results, may be mentioned. Most foundries no doubt could point to similar experiences. However, the significant thing for consideration should be the method used to arrive at the objective.

For example: To train the crane operators an experienced craneman, who seemed to possess special aptitude as an instructor, was selected. He was given help to prepare the description and explanation which could be given as related instruction in a classroom; then arrangements were made for the use of a particular crane and he was helped to organize the steps by which the operation of the crane was to be taught.

In the case of the women who became coremakers and mold finishers, a special program of related instruction and actual experience was lined up with the aid of the local vocational school, and the trainees were given their two weeks of training in a classroom in the high school.

In short, in each case an attempt was made to arrive first at the answers to the question "What is to be Taught," "Where can it be Taught," "How can it be Taught," and "Who Should do the Teaching"? It is certain that these questions must be answered in every case and that there must be someone whose responsibility it is to work out the answers.

Interest in Training

Today, in thinking of training crane operators, perhaps only one or two being necessary in a month, the "Where" and "How" questions would find an entirely different answer. First of all, everyone concerned with training, from topmost management to the newest assistant foreman, must be convinced that planned training is an integral part of the line organization, in war or peace.

Someone must have the responsibility for directing and organizing specific training programs to meet specific needs. That someone must be informed fully of production plans and schedules which involve new employees for old jobs, or old employees for new jobs. Most important of all, he and the entire organization must be made to understand that he has the full and active support of top management. After that, it is up to him.

It is his job to work out reasonable and practicable plans for assisting the shop supervisors in their training problems. He has to get the answers to the "What and Where and How and When and Who." Perhaps the answer is right in the department, on the job with the foreman doing the work. It may be in a classroom or in a corner of the shop with an expert called in. Whatever the answers, the plan should be thoroughly made, properly executed, and adequately followed up. The results will show in lower costs, lessened turnover, quicker deliveries and better labor relations.

Battelle Appointments

FELLOWSHIPS AND associateships will be awarded this fall to men qualified for advances in industrial research by Battelle Memorial Institute, under a training program in operation since 1931. A limited number of Graduate Research Fellows and Postdoctoral Research Associates will be appointed to conduct investigations of a fundamental character in the Battelle laboratories.

Fellowships are open to men seeking their Master's or Doctor's degree in universities and engineering schools, and are available normally during the year at the end of which the holder expects to receive his degree.

Associateships are open to young men who have completed their academic training prior to coming to Battelle and have shown exceptional aptitude for research, either as graduate students or in a brief experience in industrial laboratories. Preference is usually given those holding a Ph.D. degree.

Full details may be obtained from Dr. J. R. Van Pelt, Battelle Memorial Institute, Columbus 1, Ohio.

STEEL CASTINGS AND WELDMENTS RESIDUAL STRESS RELIEF

C. R. Jelm
and
S. A. Herres

RESIDUAL STRESSES are elastic stresses which exist within a body as a result of non-uniform plastic deformation which may have been caused by thermal gradients, phase transformation gradients, and hot or cold working during fabrication or in service. They are present in all metal structures regardless of how they are fabricated, but their intensity may vary and may at times be controlled from immeasurably small to extremely high values depending upon the material, the fabrication process, and the prior service.

Residual stresses are known to cause undesirable dimensional changes in fabrication and service and at times to affect adversely the service properties of structures. It is therefore important to study the methods of controlling and reducing residual stresses.

Residual stresses may be relieved by: (1) removal of stressed metal which usually results in deformations due to the release and rebalancing of the residual stresses (the cause of machining instability); (2) conversion of the elastic stress to plastic strain which can be accomplished by appropriate deformation under external loading and by thermal treatment.

The first method has no important commercial application as a means of relieving stresses. Shot blasting, tumbling, peening, hydrostatic and proof loading, or limited cold work are utilized in certain special applications. The most important and the most widely applied means of relieving residual stresses is by the thermal treatment.

The purpose of this report is to review and correlate test methods and available data on the thermal relief of internal stresses and to indicate the factors involved in selecting the most practical thermal stress relieving cycles.

It has been known many years that internal stresses did exist and did affect the fabrication and service characteristics of metals[1,2,3,4] and that their elimination was in many cases essential to secure machining stability and to prevent warpage or distortion and premature failures in service, but no reliable quantitative data on their magnitude or relief were developed until comparatively recent times.

Barrett[12] in a review of the methods of internal stress measurement and their history reported that Kalakuzky[5] in 1889 made the first quantitative determinations of internal stresses in iron cylinders; somewhat later Heyn and associates[4,6] and Howard[7] in the period 1910-1915 developed similar methods of calculating the stresses in simple objects by measuring the dimensional changes on machining.

However, work by Sachs[8] in 1927 showed that the calculations of these investigators and others who used their systems were considerably in error due to certain erroneous assumptions. It was, nevertheless, be-

Available literature and data on the relief of residual stresses by thermal treatment have been reviewed and analyzed. Three basic methods have been utilized in determining the effects of stress relief annealing: (1) determination of the residual stresses or movement upon machining an actual part or structure before and after annealing; (2) determination of the remnant elastic extension or bend after annealing suitable specimens prestressed in a jig, such as a bolt fixture, or a strip specimen bent to a predetermined radius; (3) determination of a stress-time curve by loading a tensile specimen at an elevated temperature and reducing the load to maintain the gage length constant at the initial extension. The relief of stresses during annealing is due to the combined action of the reduction in yield strength of the material on heating to elevated temperatures and creep under decreasing stress. This latter effect decreases at temperature with decreasing stress level.

Analysis of the available stress relief data indicates that at the present time (i.e., within accuracy of present test methods) the percentage relief of residual stresses, brought about by stress relieving in the temperature range of 750° to 1300° F., appears independent of steel type, composition, or yield strength. However, the higher the original residual stresses the higher will be the remnant stresses after a given thermal stress relief treatment.

NOTE: The statements or opinions expressed herein are those of the authors, C. R. Jelm, formerly associate metallurgist, Watertown Arsenal, Watertown, Mass., and S. A. Herres, Captain, Ordnance Department, Watertown Arsenal, Watertown, Mass., and do not necessarily express the views of the Ordnance Department. Presented at a Steel Session of the Fiftieth Annual Meeting, American Foundrymen's Association at Cleveland, May 8, 1946.

fore this time that the relation between internal stresses and "season cracking" of brass was determined and a method for its prevention by thermal treatment developed[9,10,11].

Several papers on the thermal relief of residual stresses were published prior to 1930[2,13,14,15,16,17], but for the most part these qualitative discussions failed to amplify or clarify existing concepts on the relief of stresses in ferrous materials which were established prior to the turn of the century. Quantitative data when presented were likely to be misleading. The results of several quantitative investigations and reviews[18-26] have been presented in the past few years but the need for more and accurate data on the thermal relief of stresses is apparent from the paucity of the existing reliable data.

One of the chief difficulties in the study of the relief of stresses has been the development of suitable test methods which would permit simple accurate determination and control of the initial and final residual stresses and a comparison of the efficiencies of various stress relieving cycles which could be translated into the service or fabrication requirements of the individual application.

Structure Tests

There are three basic methods which have been used and are being used at the present time. For lack of better annotations these will be termed for the purpose of discussion "structure tests," "simulated structure tests," and "constant gage length tests"; they are discussed in detail in the subsequent paragraphs.

Structure Tests. Perhaps one of the oldest and most common methods of obtaining data on the relief of internal stresses and the one which is most readily applicable to specific individual problems is the "structure test." This test method consists of subjecting an "as stressed" structure, such as quenched or cold drawn or rounds, tubing, castings, simple welded structures, etc., to desired thermal treatments and subsequently determining the dimensional changes upon machining in an appropriate manner. By comparing these measurements, or the calculated stresses, to those of the "stressed" structure the efficiencies of the different cycles can be determined.

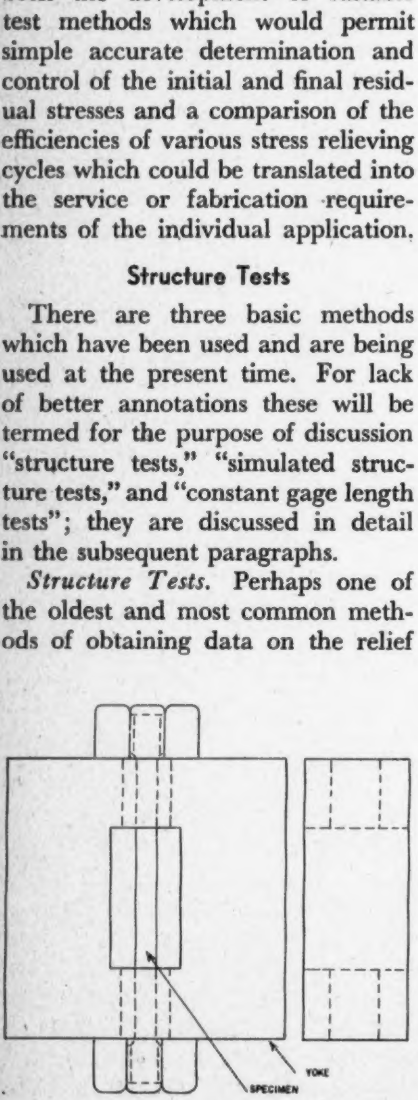


Fig. 1—Schematic diagram of stressing jig (Stewart Method).

Stress Calculations

Because of the relative simplicity of the stress calculations in rounds and cylinders, the use of this type of structure has been popular. Heyn[4] in 1912 obtained quantitative data on the thermal relief of stresses in cold drawn rounds by this method, and it has since been employed and refined by other investigators[27-33]. Cold drawn and heat-treated tubing[34-36] have been used, as have ring, hoop, wheel and hub and other specifically designed castings[37-42]. Simple welded structures have been utilized in some instances[20,43]. X-ray determination of surface stresses in cold drawn and annealed wire was conducted by Faggiani[44]; this method of stress determination has been discussed by others[12,45].

Except for parts identical to those under investigation, the relief data obtained by this method are not generally applicable unless special precautions are taken. In the first place, the determinations of the actual stress values are difficult and tedious to perform in other than the most simple shapes[22,36] and are very likely to be only approximate.

In several of the investigations only single deflection measurements were made, such as in the slitting of rings[37-38], tubing[34], spokes of hub and wheel castings[41-42] or other similar structures[40,43]. Stress calculations in such cases are very likely to be in error and may be entirely misleading.

When the percentage reduction in movement upon sectioning is determined as a function of annealing temperature and time, the results are probably an approximation of the relief of stresses in that structure, but they cannot be interpolated to other structures unless the actual stress magnitudes are known, both before and after annealing.

Not only is the determination of stresses in structures difficult, but control of the magnitude and distribution is virtually impossible. They must generally be accepted as they develop and exist. As the relief of residual stresses depends to a certain extent upon their severity, as shown later, the data obtained with one initial stress magnitude and distribution cannot be readily applied to another structure where the conditions are not the same. It is, therefore, evident that the "structure test" is difficult to perform and the data difficult to apply to other than specific applications.

Simulated Structure Tests. Owing to the difficulties and disadvantages of the structure tests, other test methods have been developed which afford greater control of the original stresses and an easy determination of the residual stress values. Benson and Allison[47], Moore and Beckinsale[9] and others[46-53] have developed such methods.

Naval Research Method

The method developed by Stewart[49] at the Naval Research Laboratory, and later applied by Beyma[51] and Cunnick and McDowell[19], is probably the most convenient and readily interpretable of the group. This consists of a simple yoke jig and an ordinary tensile specimen as shown in Fig. 1. By tightening the nuts at either end of the specimen any desired tensile strain can be applied (it may be desirable to key the specimen to prevent the establishment of torsional stresses).

The assembled jig is then placed in a furnace and subjected to a stress relieving cycle. After allowing the assembly to cool completely to room temperature, the nuts are loosened and the amount of residual elastic strain is determined. Since the initial and final elastic strains are known the percentage relief can be easily calculated and the actual stress values can be determined by multiplying by the elastic modulus.

Slightly modified forms of this test have been used by other investigators[47,52]. Benson and Allison[47] applied the initial stress by shrinking the specimen from an elevated temperature over a closely machined two-section sleeve. Mochel[52] used a

sleeve instead of the large yoke to support the specimen.

In using this test method certain simple precautions are necessary to obtain reliable results. First, the yoke and the specimen should be constructed from the same materials in order to avoid differences in the thermal coefficients of expansion; a difference as small as 0.5×10^{-6} in. per in. per °F., such as can easily exist between two types of steel, may result in an error of the true stress value of 15,000 psi. after cooling from 1000° F.

Second, the heating and cooling rates of the assembly must be slow enough that no significant temperature differences develop between the yoke and the specimen.

Third, the ratios of the cross-sectional areas of the specimen and yoke should be properly adjusted—two arrangements are possible which offer the least chance of introducing an additional variable due to the different rates of relief of the different stresses in the two sections: (a) the areas of the specimen and yoke approximately equal, and (b) the area of the yoke many times larger than that of the specimen. The latter condition approaches the stress distribution in welds where high tensile stresses exist in and along weld, balanced by comparatively low compression stresses outside weld zone.

Other simulated structure tests consisted chiefly of strip specimens elastically bent to a desired radius, secured, and subjected to a thermal cycle after which the remaining elastic bend, or "spring back," was determined on unclamping. The maximum initial and final stresses were calculated from the following beam formulae:

$$S = \frac{Et}{2r} \qquad S^1 = \frac{Et}{2\,(r^1 - r)/r \times r^1}$$

where S and S^1 are the initial and final stresses, t the thickness of the strip, and r and r^1 the radii of the strip as bent and upon unclamping. This type of test with modifying features has been used by many investigators[9, 46, 50, 53].

This latter simulated structure test does not appear as simple as the Stewart method, but may be more convenient in special cases. Similar precautions have to be taken in the choice of clamping materials to avoid differences in the thermal coefficient of expansion, and the thickness and radii of the strip have to be closely determined. The formulae for the calculation of the initial and final stresses assume that the stress distribution within the strip varies linearly from maximum tension at the outer fibres to maximum compression at the inner fibres.

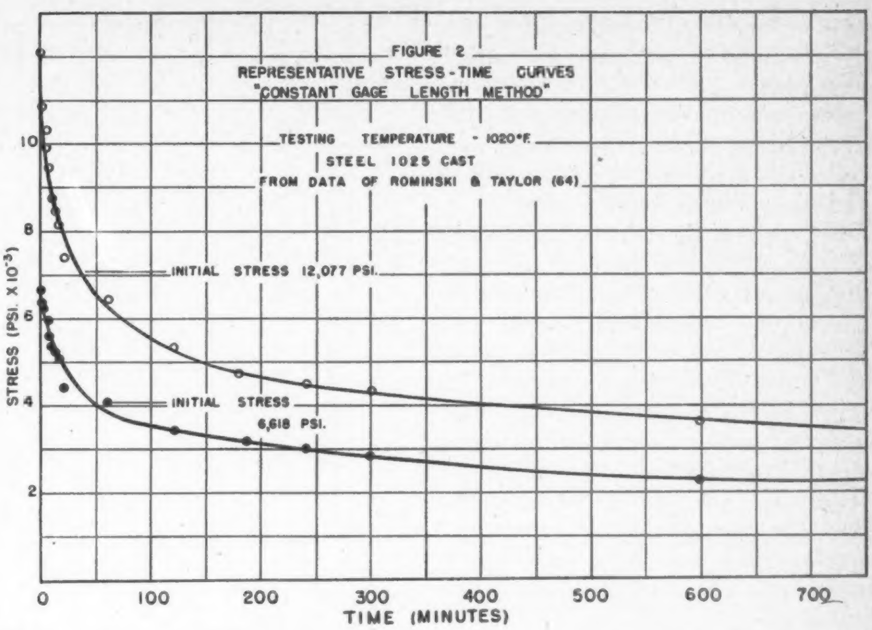


Fig. 2—Representative stress-time curves (Constant Gage Length Method).

Stress Relieving

If the initial applied stress exceeds the elastic limit, the calculations are no longer valid; and, in any event, after stress relieving, the assumed condition is no longer present as the higher surface stresses are relieved more rapidly than the lower stresses in the center of the strip destroying the linear distribution as pointed out by Scott[50].

Constant Gage Length Tests. As the structure and simulated structure tests require an extensive number of tests to investigate the effect of holding time on the relief of residual stresses and involves a variable factor in the heating and cooling rates, a third test method has been developed. Briefly, this method of testing consists of loading a suitable tensile specimen to a desired stress (or extension) at an elevated temperature and subsequently reducing the applied load to maintain the gage length constant by reducing the elastic strain to compensate for the plastic extension due to creep. Two stress-time curves are shown in Fig. 2.

This type of test was conducted by Mailander[54-55] in 1931 in studies on two Cr-Ni steels and has since been used extensively in the study of the relaxation of stress in bolts[56-63, 65-67] and occasionally in the study of stress relief[61, 64]. Detailed descriptions of the apparatus used in this test are given by Boyd[58] and Nadai and Boyd[63]. A modified form of the test was used by Betty, MacQueen and Rolle[68] in the study of nickel alloy springs.

The advantages of this method are evident; it offers close control over the applied stress and the residual stresses are simply and continuously determined with appropriate apparatus. Only a single test need be run at one temperature and stress level to determine the effect of time, whereas several tests of either the structure or simulated structure types would be required. Finally, the data are more readily interpreted quantitatively, as will be discussed later.

The disadvantages are that in order to translate the applied and residual stresses at the elevated temperature to similar room temperature conditions, the modulus of elasticity of the material at the testing temperature should be known; this property is difficult to determine at high temperatures. Secondly, changes in the density or specific volume of the material may introduce a considerable error in the results as related to the stress relief of a structure; a change of as little as 0.0002 cm.^{3} per gm. in the specific volume during the test will cause a change of about 6,000 psi. in the remnant

stress. Similarly, small changes in the modulus of elasticity will alter the results.

Changes in the properties of the steel during the test may have an effect on the relief of the stresses, and their determination may be necessary for complete interpretation of the data. Finally, in the constant gage length tests all relief occurs at the testing temperature while in actual stress relieving cycles a great portion of the relief occurs over a range of temperatures during heating; to apply the constant gage length test data to the specification of thermal cycles it must be assumed that the temperature of relief on heating does not effect the remnant stress values as determined by this method.

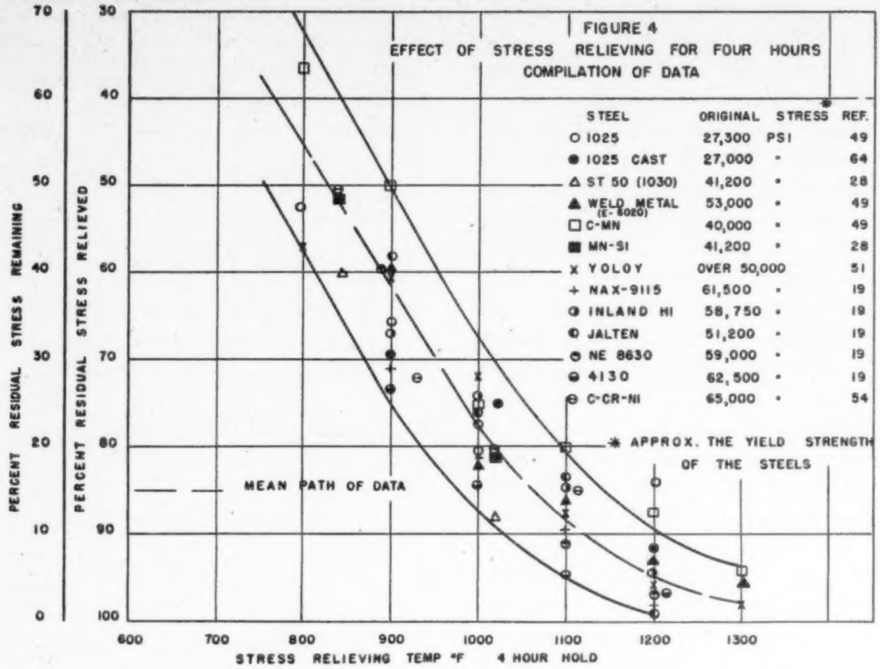


Fig. 4—Effect of stress relieving for 4 hr.

Data Compilation and Correlation

Data on the effect of annealing on the residual stresses in steel are surprisingly meager; Figs. 3, 4 and 5 represent a compilation of most of the existing data on thermal stress relief. The soaking times of 1, 4 and 8 hr. were chosen because more data were available for these holding times than for others. Data existing for other miscellaneous soaking periods would have added little to this presentation; reference has been made to these investigations previously and they are noted in the bibliography.

There is considerable scatter in the plotted data. Most of this can be accounted for by variations in the heating and cooling rates among different investigators, discrepancies between actual and recorded temperatures and times at temperature, errors in strain measurements and stress calculations, etc.

As the plotted data include the results of many different types of steel varying in alloy composition and strength, part of the variation may be due to differences in the steels, as well as to the different types of stress measurements and methods of investigation. However, analysis has indicated that both the mild steel and the alloy steel data are distributed approximately equally between the extreme values of the data. All the values fall within a range of ± 15 per cent maximum to ± 5 per cent at the higher stress relieving temperatures and longer holding times.

Both the meagerness and the scatter of the available data prevent the establishment of any reliable conclusions on the effect of alloy content on the thermal relief of residual stresses in steel at the present time. The need for additional accurate data obtained under controlled and reproducible conditions is apparent. For these reasons it is believed that at the present time, the most useful summation of the data is a plot of the mean paths of the data of Figs. 3, 4, and 5 as shown in Fig. 6. On the basis of the present knowledge, this figure represents an approximate working basis for the specification of thermal stress relieving cycles for most structural ferrous materials.

Different materials may behave somewhat differently, but lacking specific information on the steel and structure under consideration, Fig. 6 can be used as a guide with assurance of its accuracy within the limits cited previously. Most of the

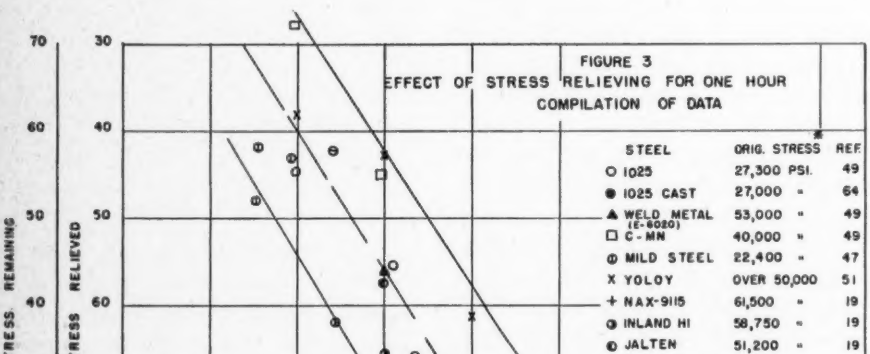


Fig. 3—Effect of stress relieving for 1 hr.

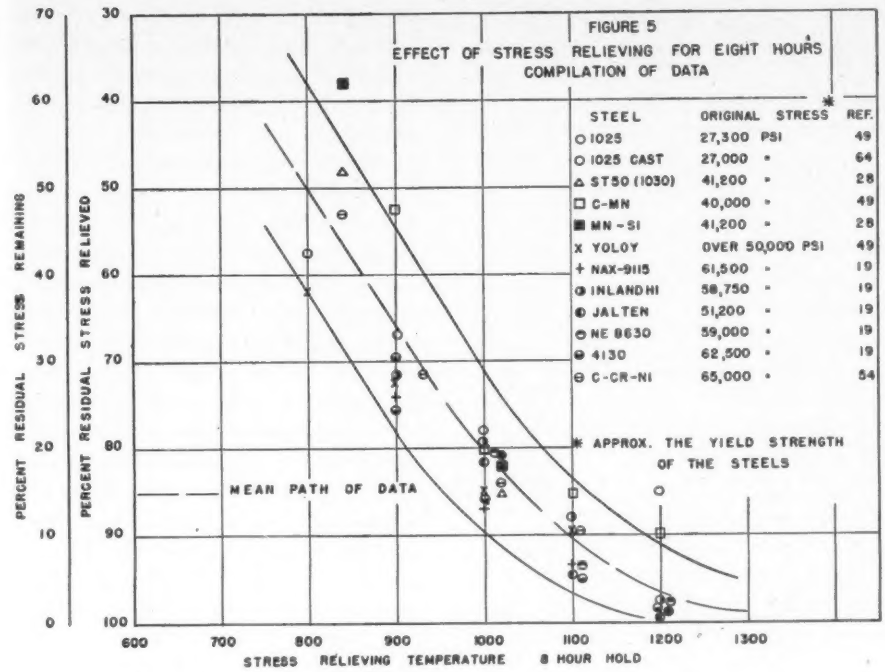


Fig. 5—Effect of stress relieving for 8 hr.

data presented were secured on uniaxially stressed parts or specimens; in service structures the internal stresses are generally multiaxial. The effects of this condition on the relief of stresses have not been determined.

Certain amplification is, however, desirable. In Fig. 6 the effect of time of stress relieving is evident; this varies somewhat with temperature. At 900° F. increasing the soaking time from one to four hours is equivalent to increasing the temperature of annealing to 935° F.; at 1150° F. this same increase in time is equivalent to raising the temperature to 1200° F. Further increasing the time of hold from 4 to 8 hr. is roughly equivalent to raising maximum temperature of cycle 20° F.

The total effect of increasing the time of hold from one to eight hr. or the temperature 55° to 70° F. is to reduce the stresses an additional 9 per cent at 900° F. and 5.5 per cent at 1150° F., a relatively small factor when it is considered that the total reduction in the residual stresses at these temperatures is 65 per cent and 94 per cent, respectively. The relative effect of increasing the time of annealing decreases with increasing temperatures, at least above 800° F.

Discussion heretofore has been confined to the percentage relief of stresses and not to actual stress values; it is apparent that the two are not the same. If two structures built of materials of 30,000 to 60,000 psi. yield strengths with internal stresses approximating these values, are stress relieved to eliminate 50 per cent of the stress (825° F. for 4 hr.), it is obvious that the first will have a maximum remnant residual stress of 15,000 psi. and the latter 30,000 psi., equal to the maximum initial stress of the former.

To illustrate this condition more effectively, Fig. 8 has been prepared from the data of Fig. 4, plotting the maximum residual stress values as a function of stress relieving temperature (4-hr. hold) for three different classes of steel having yield strengths of 30,000, 50,000 and 70,000 psi. and initial residual stresses approximately equal to these values. If, for example, it is desired to reduce the maximum residual stress to 10,000 psi., it would be necessary to treat the 70,000 psi. yield strength steel at 1070° F., the 50,000 psi. yield strength steel at 1020° F., and the 30,000 psi. yield strength steel at only 920° F.

Reduce Residual Stress

The difference of 150° F. in the maximum stress relieving temperature is worth considering. This effect has also been considered as a function of soaking time in Fig. 7—to reduce the residual stress in a 50,000 psi. yield strength steel to 10,000 psi. maximum, eight hours are required at 990° F., four hr. at 1020° F., and only one hr. at 1055° F. Similar calculations can be made for other desired stress conditions and steels from Fig. 6 data.

It must be recalled that the foregoing data and discussion have referred only to residual stresses which were initially approximately equal to the yield strengths of the material. In welded structures, quenched

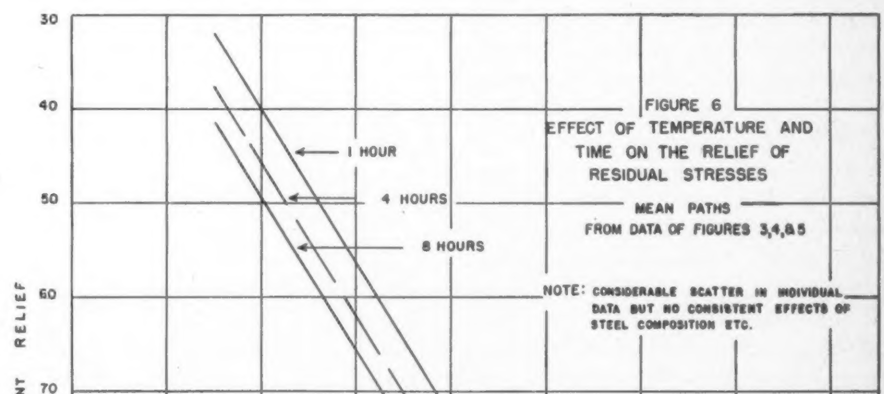


Fig. 6—Effect of temperature and time on the relief of residual stresses.

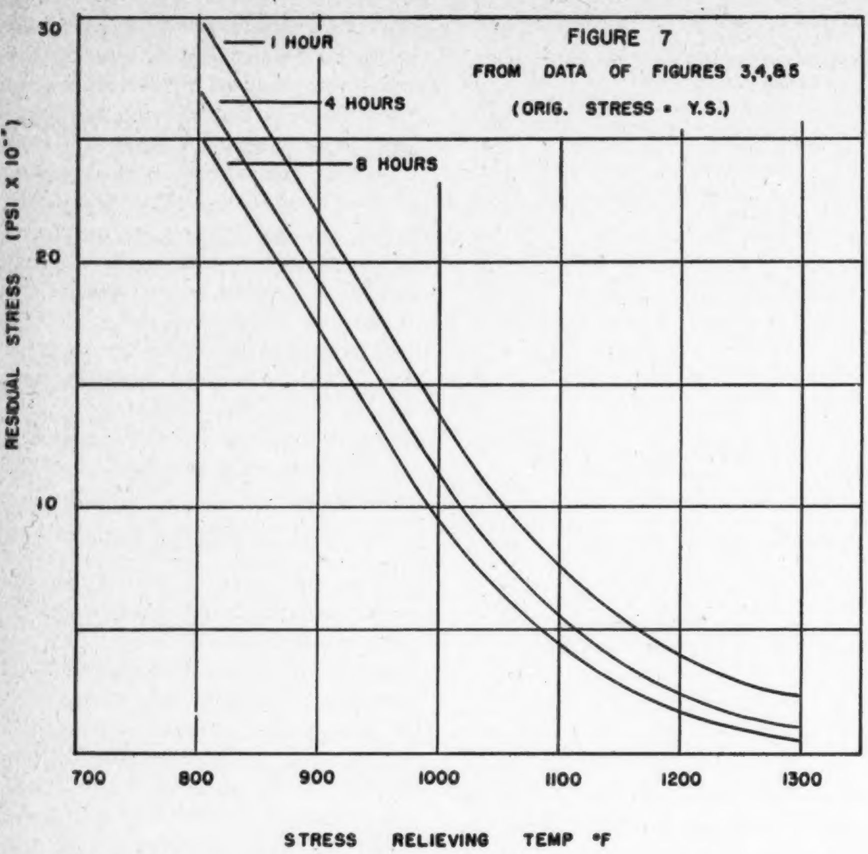


Fig. 7—Effect of stress relieving temperature and time on the residual stress of a 50,000 psi. yield strength steel.

the initial stress difference was 20,000 psi. the final stress difference was only 1,500 psi. In general, the higher the stress relieving temperature and the longer the soaking the less will be the effect of initial stress level on the final stresses.

The relief of internal stresses by thermal treatment can be considered due to the transformation of elastic strain (stress) to plastic strain. This is accomplished by the combined action of reducing the yield (flow) strength of the material on heating to an elevated temperature and creep. These two actions, though related, can be most conveniently considered as two distinct factors. Except under conditions of constraint or suitably combined stresses a material will not support stresses, either external or internal, in excess of its yield strength (as measured in the tensile test) without deforming plastically.

On heating, the yield strengths of most materials are lowered appreciably as shown in Fig. 11, and as a result the internal stresses are lowered due to the decrease in the elastic strain. Also, as is generally known, metals at elevated temperatures (some even at room temperature) flow plastically under stresses which are considerably less than their yield strengths—this behavior is known as creep. In stress relieving this occurs in a somewhat different

parts, structures quenched or rapidly cooled from the tempering temperature, and some "as cast" structures generally approach this condition. This is readily apparent when it is realized that a temperature differential within a structure of only 200° F., established at a sufficiently high temperature so as to be initially stress-free, will cause a final residual stress at room temperature of about 45,000 psi.

There are, however, many instances when the residual stresses are less than the yield strengths of the steels. Unfortunately, insufficient data are available to present a quantitative analysis of the effect of initial stress level, but its effects are illustrated in Figs. 9 and 10, derived from the data of Mailander[54]. Two stress levels, 30,000 psi. and 50,000 psi., for a Ni-Cr steel are represented. Fig. 9 shows that the percentage relief of stresses is greater in the specimens with the higher initial stress, and Fig. 10 that the actual remnant stress values are also higher. It can be qualitatively expressed that the higher the initial stress the greater the percentage relief, and the higher the residual stress values after any given thermal cycle, limited, of course, by the values which can be calculated from Fig. 6.

In the usual stress relieving range of 1000° F.—1200° F. in the illustrated example (Fig. 10), though

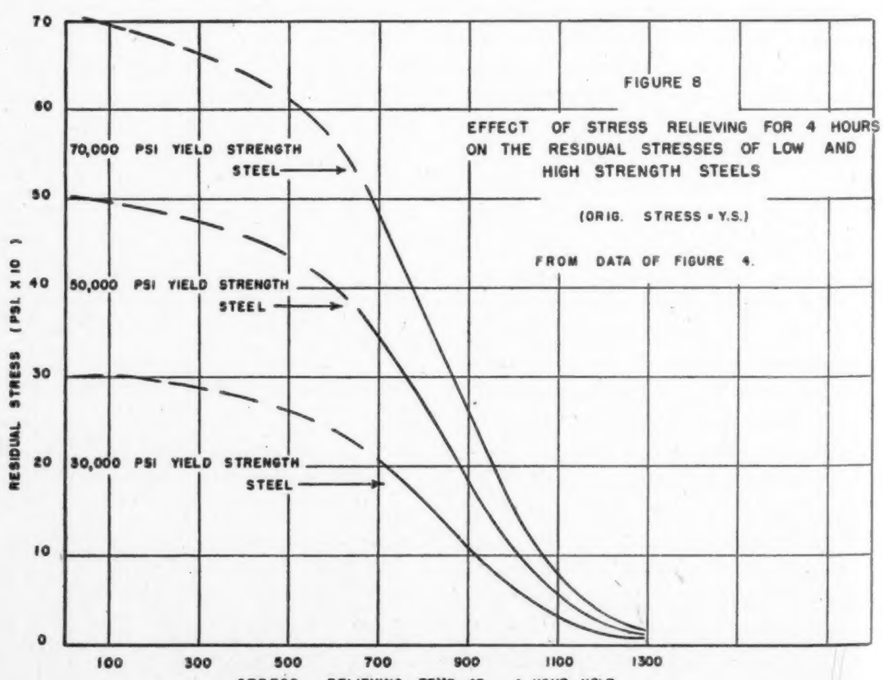


Fig. 8—Effect of stress relieving for 4 hr. on the residual stresses of low and high strength steels.

form than determined in the creep test as the total strain, not the load, is maintained essentially constant which results in a continual reduction in stress due to the plastic flow which occurs. The phenomena of creep under decreasing stress has been termed "relaxation." It occurs on heating up into the creep range (above 400°-500° F. in most steels) while holding at temperature and during cooling from the annealing temperature.

The amount of stress reduction which occurs due to relaxation in a given steel depends upon their rate of heating, maximum temperature, the holding time, and the rate of cooling. The higher the temperature and the longer the time spent in heating and cooling and at temperature the greater is the relative effect of the relaxation. As temperature is one of the chief determining factors of the rate of relaxation, the rate of cooling from the annealing temperature will have only a small effect on the relief of the stresses as the stresses have been reduced to such a point by heating to and soaking at temperature that further relaxation can only take place to a very limited extent.

If the structure is held at the annealing temperature for any reasonable length of time, the rate of heating becomes relatively unimportant as the stress reduction due to relaxation which occurs in any normal heating-up period would also occur in a few minutes while holding at the maximum temperature. The effect of holding at temperature can be most readily discussed with reference to Fig. 2. The relaxation of the stresses is initially quite rapid but the rate decreases rapidly as the stress is reduced, and after a relatively short period of time further reduction is limited. In Fig. 2, the 12,000 psi. initial stress has been reduced to about 5,000 psi. in 2 hours; holding an additional 10 hours at temperature will reduce the stress only another 1,500 psi., a negligible amount considering the time factor involved.

At higher temperatures the relaxation curves are steeper and the leveling off occurs in a shorter time. For example, at 1200° F. one hour accomplishes most of the relief, and at 1380° F. 15 to 20 minutes is ample[64].

The effect of holding time on the relief of stresses can be quantitatively analyzed from relaxation data. Rominski and Taylor[64] suggested that the rate of relief could be expressed as a function time such that

$$-\frac{dS}{dt} = mt^{-1}$$

which when integrated gave

$$S = -S_0 \log \frac{t}{t_0}$$

where $\frac{dS}{dt}$ is the rate of relief, S the stress, t the time and m, S_0, t_0 appropriate constants. This analysis appears approximately to represent the data but extrapolation of the stress-time formula to zero time (the beginning of the test) shows that the initial stress would be infinitely large and in the other direction that the internal stress is eventually completely effaced; an impossibility as indicated by other investigators[52, 56, 58, 61].

There appears to be no physical basis for considering the rate of relaxation as a function of time as the properties of the material remain substantially the same throughout the test. The fact that the relaxation tests of Rominski and Taylor[64] at the higher temperatures completely relieved the applied stress can be accounted for by the insensitivity of the apparatus.

It appears more feasible that the rate of relief would be a function of

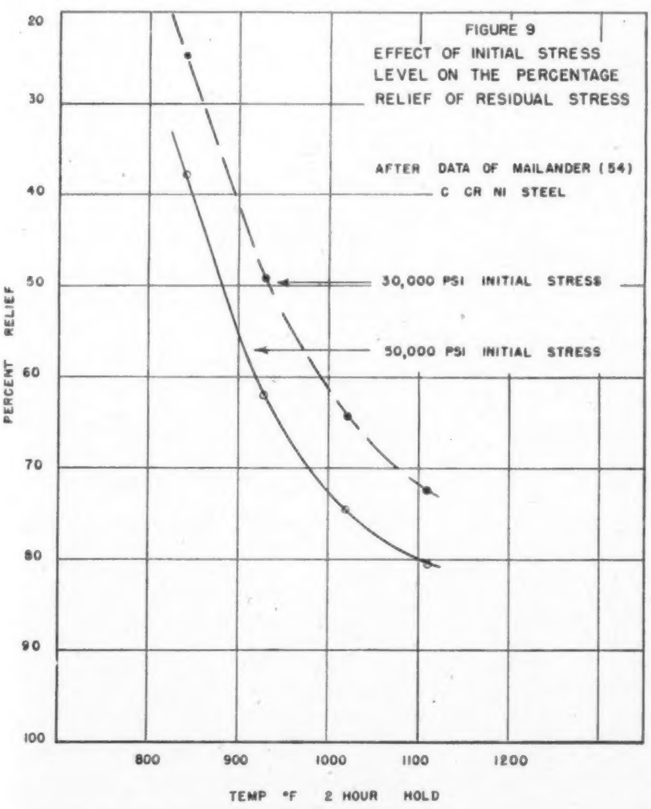


Fig. 9—Effect of initial stress level on the percentage relief of residual stress.

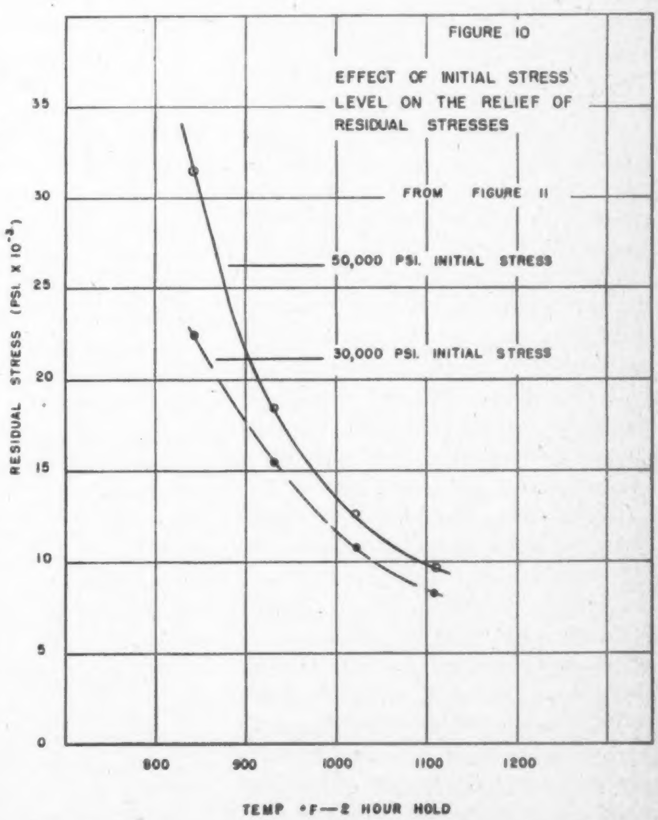


Fig. 10—Effect of initial stress level on the relief of residual stresses.

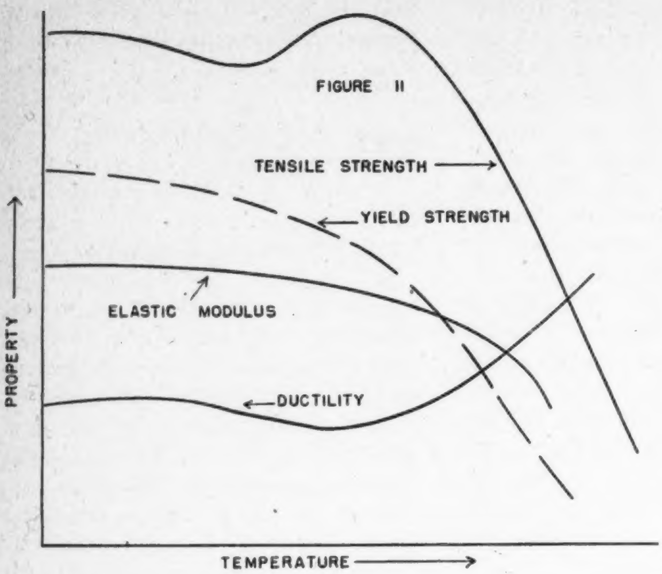


Fig. 11 (above)—Schematic representation of the effect of temperature on the tensile properties of steel.

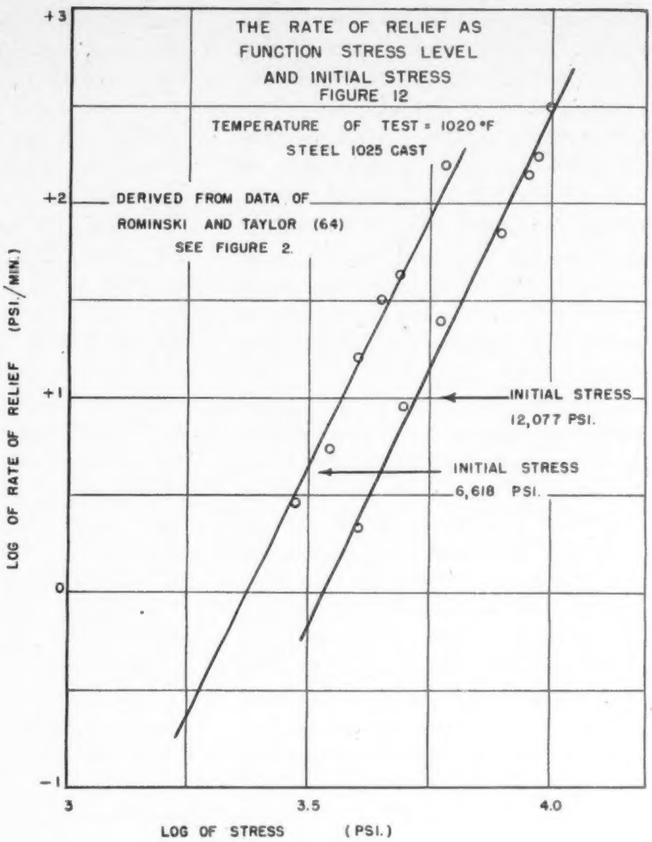


Fig. 12 (right)—Rate of relief as function stress level and initial stress.

the applied stress. The stress-time curves of Fig. 2 are replotted in Fig. 12, where the log of the rate of relief is plotted vs. the log of the stress. It will be noted that the best representation of the data is a straight line. This line can be represented by the equation

$$\frac{dS}{dt} = KS^n \quad (1)$$

where $\frac{dS}{dt}$ is the rate of relief at stress, S the stress, and K and n are constants, n being the slope of the line. The remainder of the data of Rominski and Taylor[64] can be interpreted by this formula as can the data of other investigators[54, 58, 62]. Bailey[56], Robinson[57] and others in the study of the behavior of bolts similarly developed this rate-stress relationship.

Integration of this relationship gives the stress as a function of time

$$S = [(n-1)\ Kt + S_i^{1-n}]^{\frac{1}{1-n}} \quad (2)$$

where S is the stress at time t and S_i is the initial stress, K and n being the same constants as before. Insufficient data of the proper nature are available at the present time to evaluate completely the effects of time and steel composition and treatment on the constants of the equation, but if and when such data does become available the stress relief behavior of various steels can be readily compared by a consideration of these constants. Analyses of the data of Mailander[54] and Rominski and Taylor[64], however, indicate that n, the principal shape factor of the stress-time curves, decreases rapidly with increasing temperature.

Another effect of heating on the elastic properties of metals which effects the relief of stresses is also illustrated in Fig. 11; i.e., the modulus of elasticity decreases with temperature. The effect of this is to decrease the stresses existing at the elevated temperature even if no plastic deformation has occurred. For example, if the elastic modulus is decreased 50 per cent, the internal stresses also would be reduced 50 per cent as the strain remains constant. Unfortunately, this effect is reversible, and if no plastic flow occurs due to other considerations the stresses will return to their original values on cooling the structure or specimen to room temperature.

In interpreting stresses applied or existing at an elevated temperature, as in the constant gage length tests, it is necessary to multiply them by a factor $\frac{E_0}{E_t}$, where E_0 and E_t are the elastic moduli at room and elevated temperatures respectively[54] in order to obtain the corresponding stresses which would exist at room temperature under similar strain conditions. Determinations of elastic moduli at elevated temperatures, above 900° F., are difficult and are not reliable unless obtained dynamically.

The size or thickness of the structure does not affect, as is occasionally inferred, the relief of residual stress. The only consideration as to soaking time that need be given to size is to insure that all portions are heated to the desired elevated temperature. With large sections the soaking time to insure temperature uniformity is naturally greater, but once the structure is *at temperature* its size need not be considered as affecting the relief of stresses.

Application of Data—Principles

The most common thermal treatment to accomplish the relief of internal stresses[69] is to heat the structure uniformly to 1100°-1200° F., to hold at temperature one hr. per in. of thickness of the heaviest section, and subsequently to cool slowly in the furnace. Reference to Fig. 6 indicates that anywhere from 85 to 95 per cent of the internal stresses should be removed by this treatment.

This cycle has been found to be adequate for most applications, and in some cases may have been more than sufficient.

As discussed in the previous section there are four variables in the stress relieving cycle: Heating rate, maximum temperature, time of hold, and cooling rate; and three variables in the structure—material and prior treatment, section size, and residual stress pattern. The heating and cooling rates do not significantly affect the relief of residual stresses but must be controlled because of other considerations.

Heating Rate

With complicated and heavy structures the rate of heating must be slow enough to prevent cracking and undesirable distortion due to non-uniform expansion of the structure. Likewise, the rate of cooling from the annealing temperature should be slow enough to prevent the establishment of new *harmful* residual stresses. The size of the structure does not affect the relief of stresses but must be considered in establishing heating and cooling rates and holding times to insure temperature uniformity throughout the structure at the annealing temperature and to prevent any harmful thermal gradients.

Therefore, for a given structure (material and stress pattern) the relief of the internal stresses depends principally upon the maximum temperature and the time at temperature. The effect of time and temperature on a highly stressed structure may be evaluated approximately from the data summary of Fig. 6. The present available data do not indicate any significant or consistent differences in the percentage relief of stresses with different steel compositions and types (additional accurate data are necessary). However, as discussed previously, the maximum remnant stresses increase with the strength of the steel.

The relief of internal stresses is in many instances not the only effect of annealing at elevated temperatures. Softening[70] and tempering or precipitation hardening may occur depending upon the material, annealing temperature, and time. In weldments annealing will also soften any hardened heat-affected zone which may have developed in welding and may partially release any absorbed gases. These and other effects, though they may slightly alter the stress relieving characteristics of the material, should not be considered as the predominant factor in the determination of the stress relief cycle. Nevertheless, a compromise may often be necessary to secure the optimum physical properties and maximum stress relief.

A commercial copper bearing precipitation hardening steel offers an excellent illustrative example[71]; to obtain the maximum strength a 3-hr. treatment at 900° F. is required and only one hour at 1050° F. Figure 6 indicates that 19 per cent greater stress relief could be achieved by the latter treatment with only slight reduction in the maximum strength. Similarly, the effect of temperature and time on the properties of other materials must be considered in specifying stress relieving treatments.

The elimination of residual stresses is desired for three principal reasons: (1) Machining or service stability; (2) improvement in static strength; and (3) improvement in resistance to shock restraint, progressive, and other "non-static" failures. When stress relief annealing is conducted to secure machining stability, the amount of relief necessary obviously depends upon the degree of stability desired.

Machining Stability

The machining tolerances and the clearance tolerances for operation in service, the magnitude and distribution of the residual stresses in relation to the sequence and amount of machining to be conducted, the geometry of the structure and other miscellaneous factors affect the degree of stability required, and the proper minimum thermal stress relief treatment will therefore depend upon the individual application.

The minimum thermal treatment necessary to secure adequate machining stability for the particular application can be approximated in several ways. One of the more direct ways would be to machine the "as stressed" structure to determine the amount of undesirable "walkout," estimate the required reduction in "walkout" to meet the machining tolerances or other requirements, and finally, select from Fig. 6 an approximate thermal cycle to give the desired relief. If thermal stress relieving is already being performed, the severity of the thermal cycle can in some cases be reduced; the amount of existing "walkout," the required stability, and the relief data of Fig. 6 permit a determination of a more favorable reduced cycle.

Even if machining stability is obtained the influence of residual stresses on service instability must still be considered for certain applications where the service is such that a combination of service loading and residual stresses may produce dimensional changes which interfere with proper functioning of the structure. For such applications a degree of thermal stress relief greater than that needed for machining stability alone is required.

Static Strength

The effect of residual stresses on the static strength of the structure are somewhat conjectural. It is true that the proportional limit of the structure is lowered considerably by their presence, but this has little relation to the usual design figure of yield strength at 0.1 per cent offset which is generally not appreciably affected[18]. Further, the region of high internal stress in welded and other structures in most cases represents only a small portion of the supporting dimension; therefore the improvement to result from stress relief annealing in this respect is at best small.

If improvement is sought by stress relief annealing in the resistance to shock, restraint, progressive, or other types of failure accompanied by a brittle fracture, consideration must be given to the direction, distribution, and magnitude of the residual stress existing in relation to the stresses that are to be imposed during service and the ability of the material to withstand these conditions. Residual stresses can be both favorable (as evidenced by peening of parts subject to fatigue stresses and the cold working of gun tubes) and unfavorable to failures of this type depending upon these conditions.

Without proper consideration stress relief annealing may actually make the structure more prone to failure. Discussion of stress relieving for improvement in these cases in the light of present knowledge of their mechanism would be hypothetical. However, again it should be emphasized that each application

represents a special case in itself and that no rules are generally applicable.

The reason for the desire to minimize stress relief annealing treatments is entirely economical. Aside from the obvious savings in time and fuel, a more important consideration is arising in the development and use of high strength structural steels with yield strengths of 70,000 psi. and above.

With the general practice of stress relieving in the range of 1100° to 1200° F. these high strengths can be secured only by the use of higher carbon and/or alloy additions and consequent greater fabrication difficulties, regardless of whether "hot rolled" or heat treated steels are used. Reconsideration of stress relief annealing practice may indicate that in certain applications temperatures and times of annealing cycles can be substantially reduced resulting in higher strengths with smaller alloy additions provided that the annealing temperatures are not excessive for the particular application.

Summary

Three basic methods have been utilized for various investigators for determination of the effects of stress relief annealing: (1) Determination of the residual stresses or movement upon machining an actual part or structure before and after annealing; (2) determination of the remnant elastic extension or bend after annealing suitable specimens prestressed in a jig, such a bolt fixture, or a strip specimen bent to a predetermined radius; (3) determination of a stress-time curve by loading a tensile specimen at an elevated temperature and reducing the load to maintain the gage length constant at the initial extension.

Certain differences exist among the data obtained by the three methods, but properly interpreted the results are comparable. The choice of the method to use will depend principally on the exact information desired, but the second method appears to be the simplest to control and operate and yields the most readily interpretable data.

The relief of stresses during annealing is due to the combined action of the reduction in yield strength of the material on heating to elevated temperatures and creep under decreasing stress. This latter effect decreases at temperature with decreasing stress level (Fig. 12) as expressed approximately by the relation:

$$\frac{dS}{dt} = KS^n,$$

where $\frac{dS}{dt}$ is the rate of relief, S is the stress level, and K and n are constants depending upon the material, temperature, and other defining conditions.

Analysis of the available stress relief data (Figs. 3-5) indicates that at the present time (i.e., within accuracy of present test methods) the percentage relief of residual stresses, brought about by stress relieving in the temperature range of 750° to 1300° F., appears independent of steel type, composition, or yield strength. However, the higher the original residual stresses the higher will be the remnant stresses after a given thermal stress relief treatment.

In specifying thermal stress relief treatments, it should be recognized that the requirements of various individual applications will differ widely, as to required degree of machining stability and allowable residual stress.

Other effects of thermal stress relieving treatments, such as tempering, precipitation hardening, softening of a weld heat-affected zone, release of absorbed gases, and others, should be considered independent of the relief of residual stresses, though a compromise may sometimes be necessary between optimum physical properties and maximum relief of stresses.

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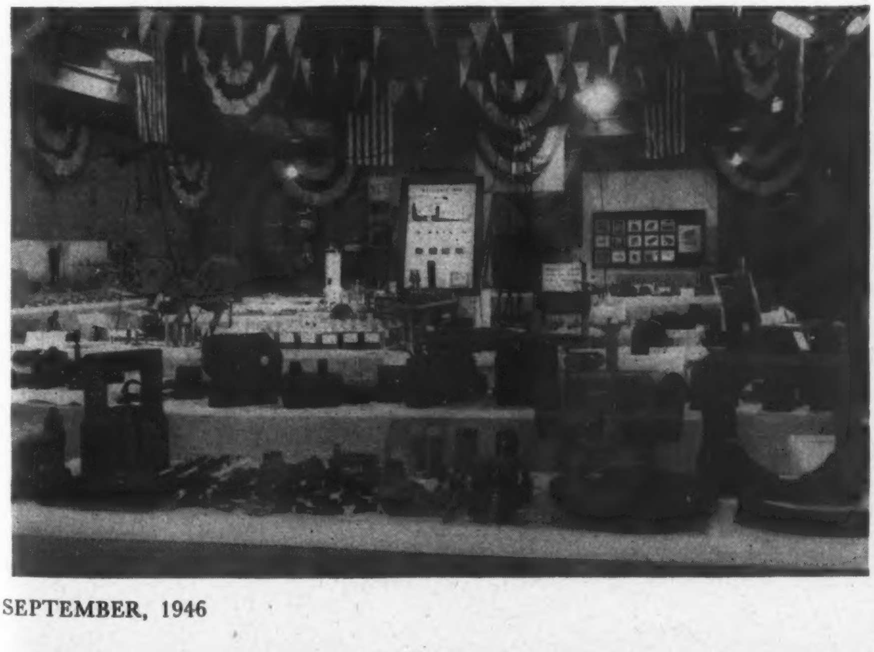
Exhibit of cores, sand samples and sand testing equipment at the recent Erie Foundry Show sponsored by the Northwestern Pennsylvania Chapter

(Photo courtesy Earl Strick, Erie Malleable Iron Co., Erie, Pa.)



Government Issues Chemical Booklet

PRECAUTIONARY MEASURES developed by the Interstate Commerce Commission, Manufacturing Chemists' Association and national and state safety organizations are outlined in "Sulphuric Acid," fourth in a series of pamphlets on "Controlling Chemical Hazards" issued by the Division of Labor Standards, U. S. Department of Labor, Washington 25, D. C. Requests for copies should be addressed to V. A. Zimmer, Director, Division of Labor Standards.

BOARD REVISES
A.F.A. Technical Groups and Programs

Recommendations approved by the A.F.A. Board of Directors at its Annual Meeting of July 26 provide for modification of technical committee organization, some revision in overall planning of technical activities, and development of a well defined A.F.A.-sponsored research plan.

Integration of all Association technical activities is the cardinal objective of the plans, which will be put into effect at once. Committee meetings now underway throughout the Association have as their purpose the accomplishment of initial steps necessary to the undertaking.

In a memorandum recently issued to all Division and General Interest Committee Chairmen and Vice-Chairmen, the National Office presents rules of organization and procedure, including a chart of "typical divisional organization predicated upon suitable inter-representation within the Division as reflected in the Executive Committee" (see cut).

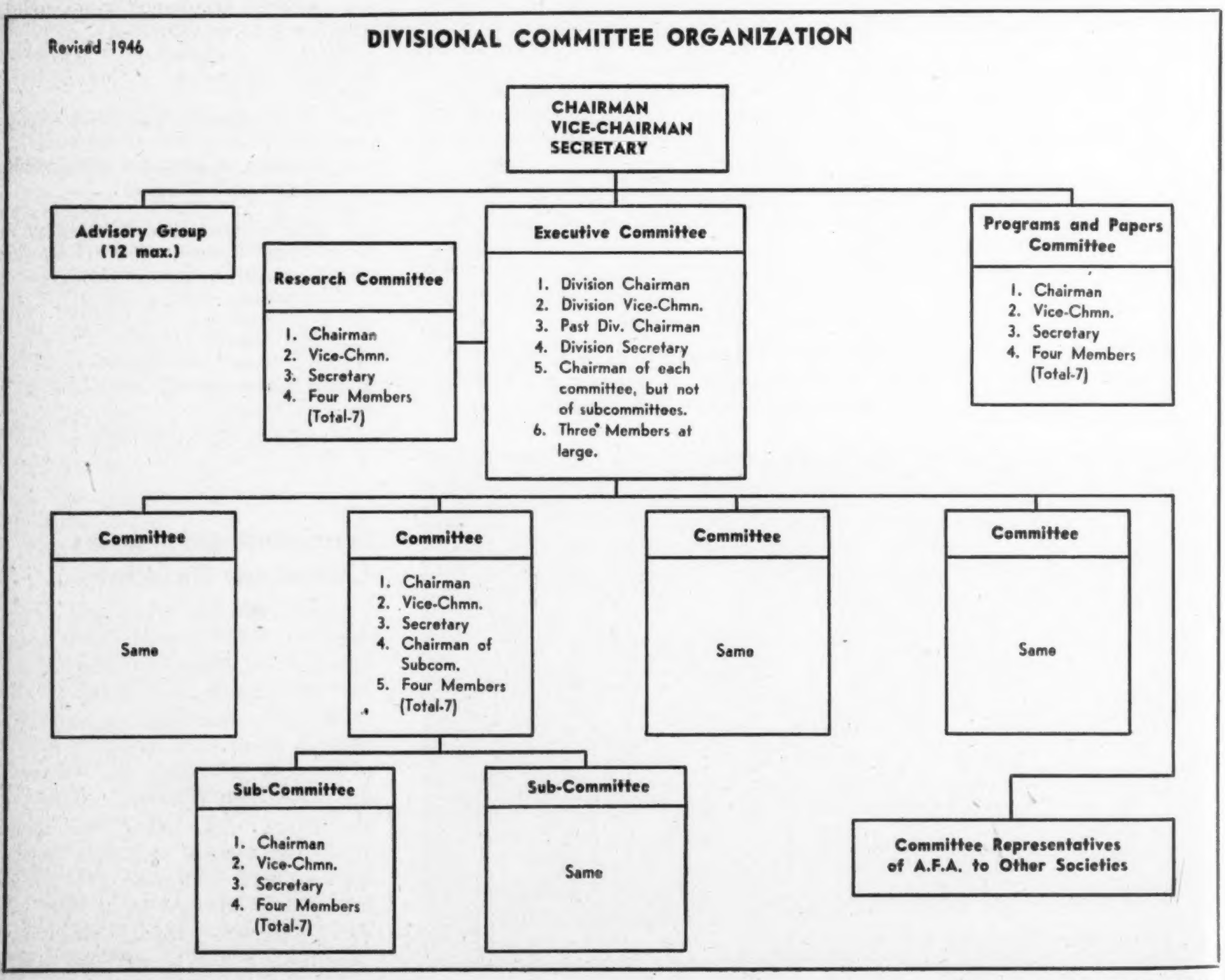
Executive Committees of Divisions and General Interest Committees are meeting to take appropriate steps in accordance with the plan. Purpose and activities of all groups under their direction will be reviewed and evaluated; and decision will be reached as to whether such groups are to be continued, disbanded or placed on standby basis (in which case a Chairman will be appointed to provide for prompt reactivation should occasion demand), and what new committees shall be established.

Following determination of their status, functioning groups will prepare a statement of purpose and scope of activities and a program for the coming year, for submittal to the Chairman of the Division or General Interest Committee. Once such purpose and program have been approved by the Chairman and Executive Committee, there will be no modification without prior approval of the latter.

In the interest of more effective operation, membership of committees is limited to seven; Chairman, Vice-Chairman, Secretary and four others, who shall include chairmen of any subcommittees. When technical committee membership has been completed and assignments accepted, the National Office will publish and send to each committee member organization charts of Division and General Interest Committees. Purpose of each committee, its program for the coming year and the names of its members will be shown, and an alphabetical list of the entire technical committee membership included.

Division Executive Committees will consist of the Division officers,

(Concluded on Page 72)



CAST IRON REPAIR WELDING

METALLURGICAL ASPECTS

J. M. Diebold
J. A. Blastic
J. A. Griffin
General Motors Corp.

Table 1

CHEMICAL COMPOSITIONS OF MATERIALS UTILIZED

Element	Test Plate Analysis, per cent	Rod Analysis — Gas Rod No. 1, per cent	Rod Analysis — Commercial Gas Rod No. 2, per cent	Pad Analysis Commercial Arc Rod, per cent
Total Carbon	3.30	3.63	3.42	3.49
Graphitic Carbon	2.9	2.78	2.91	3.46
Combined Carbon	0.39	0.85	0.51	0.03
Manganese	0.66	0.60	0.55	0.77
Phosphorus	0.149	0.60	0.61	0.90
Sulphur	0.199	0.09	0.08	0.022
Silicon	2.32	3.25	3.07	3.33
Chromium	0.16	0.14	—	0.05
Nickel	0.22	0.19	—	0.06
Molybdenum	0.02	0.02	—	0.11
Copper	0.10	0.10	—	—
Vanadium	0.025	0.05	—	—

NOTE: The nickel electrode material used was commercially pure quality of 98 per cent nickel, remainder impurities; the monel electrodes were essentially 30 per cent copper and 70 per cent nickel.

ALTHOUGH REPAIR WELDING of cast iron has been carried on for a number of years, considerable confusion still seems to exist as to what the necessary factors for correct welding procedure are and what actually takes place in the weld and adjacent cast iron during this repair operation. Some of the procedures which have been used in the past and have been developed by cut-and-try methods are not correct in all details; and, although the essential factors may be sound, some of the items involved might be not only useless but actually harmful. Recognizing this condition, the authors outlined a test and study program in an endeavor to clarify the limitations of cast iron welding and establish more functional procedures.

In reviewing the work to be done, the authors decided to limit the scope of this paper to the welding of gray cast iron by use of cast iron, nickel, or monel filler metal. While it is recognized that brazing, soldering, and the various carbon-arc techniques are also often used, the authors have tried to concentrate on the methods listed in that they are most widely used, and in the belief that the findings would be helpful even in the interpretation of those processes not included.

As a further limitation, it was decided that, in order to keep the paper within reasonable limits, only one composition of gray cast iron parent metal, two compositions of the gas welding cast iron filler metal, one composition of the cast iron arc filler metal, and one composition each of the bare and coated nickel and monel materials should be used.

A test program for the purpose of establishing the limitations of cast iron welding and developing welding procedures which will produce desired physical properties in welds and heat-affected zones is outlined by the authors. The scope of the study was limited, for reasons of practicability, to the welding of gray cast iron by use of cast iron, nickel, or monel filler metal, and further limited in respect to compositions of materials.

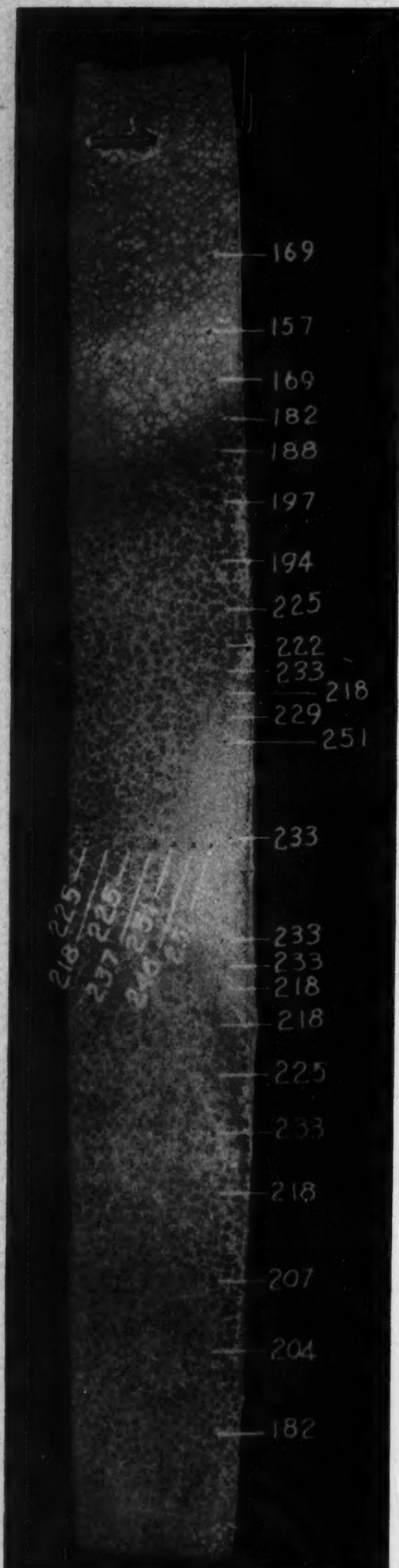
A program for the arc and gas welding with the cast iron filler metal was planned with the following preheat and postheat conditions:

1. Weld at 70° F., or room temperature (no preheat or postheat).
2. Preheat and postheat at 500° F.
3. Preheat and postheat at 1000° F., corresponding to usual practice.
4. Preheat and postheat at 1400° F., recognized as being higher than usual practice.

The monel and nickel electrodes were applied with generally accepted practice involving no preheat or postheat.

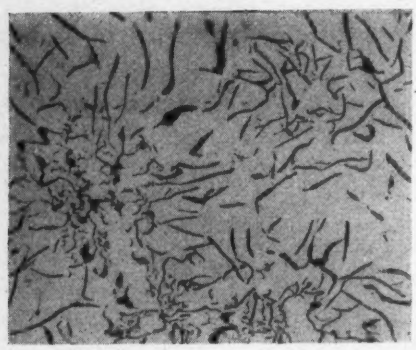
Test plates were cast under production conditions and were all from one heat of iron. (See Table 1 for chemical compositions of test plates.)

Presented at a Gray Iron Welding Session of the Fiftieth Annual Meeting, American Foundrymen's Association, at Cleveland, May 10, 1946. The authors are connected with the following divisions of General Motors Corp., Detroit: J. M. Diebold, GMC Truck & Coach Div.; J. A. Blastic, Detroit Diesel Div.; J. A. Griffin, Pontiac Motor Div.

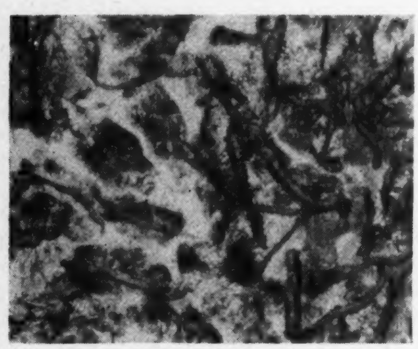


Macrosection. Vickers Brinell (10 kg.).

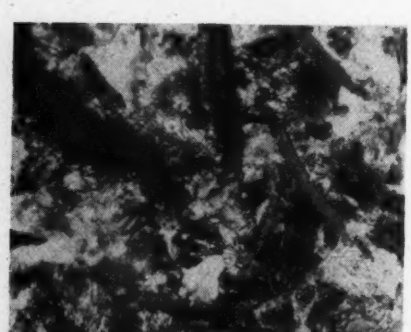
Weld. 100X



Heat-affected zone. 100X



Weld (nital etch). 500X



Heat-affected zone (nital etch). 500X

Fig. 1—Gas-weld specimen with rod No. 1, at room temperature showing hardness traverse and representative microstructure at weld and heat-affected zone, both showing pearlite matrix with steadite and carbide areas.

These plates were cast to the same size, ⅜x3x20 in., and were then cut into pieces 7 in. long for each test condition. Holes of ⅜-in. diameter were drilled half-way through the plates to serve as flaws. In the case of the coated monel and nickel specimens, it was found to be expedient to counterbore these holes in order to give better condition for fusion at the bottom. Preheating and postheating were carried on in a small laboratory-type furnace, with the welding time being held to an absolute minimum.

Postheating practice was carried on in the following manner: the 1400° F. specimens were furnace cooled to 800° F.; the 1000° F. pieces to 500° F.; and the 500° F. specimens to 200° F.; the remainder of the cooling was done in still air. The welded specimens were then cut across the filled flaw and macrosections with hardness traverses were taken of each weld, using Vickers machine with a 10-kg. load. Microstudies were made both for graphite distribution and microstructure.

Tensile test bars (0.505-in. dia.) were made, utilizing sections of mold feeders of the same material. Bars with arc and gas cast iron filler metals were made with double "V" joint preparation for the weld, which was placed crosswise of each specimen.

Since these tensile specimens were small, preheat and postheat for the gas welding was done with the torch, but furnace preheat and postheat of 1000° F. was considered necessary for the arc-welded bar. In all cases, the welding was done by the same operator under as nearly identical conditions as possible.

Gas Welding Specimens. Comparing the hardness traverses of specimens subjected to the first three heat treatments first, it will be noted that the specimens welded at room temperature (Figs. 1 and 2) show that the highest hardnesses are found not in the heat-affected zone but in the welding metal itself, with a peak hardness of 270 Vickers as compared with 250 Vickers for the heat-affected zone.

Studying the microstructure of these specimens, it will be noted that weld metal showed a medium to fine pearlite matrix with some small areas of steadite and carbides. The heat-affected zone was of a

rather heterogeneous consistency, as might be expected. Again the medium to fine pearlite formed a matrix, with some carbide and steadite areas and small amounts of ferrite making up the remainder. The parent metal was found to be of a medium coarse pearlitic structure.

Examining the hardness traverse of the 500° F. specimen in Fig. 3, it can be seen that the hardness ranges are about the same as those of the 70° F. specimens (Figs. 1 and 2). Furthermore, the microstructures closely approximate those of the specimens at room temperature.

At 1000° F. preheat and postheat, the hardness range still remains at about the same as shown in Fig. 4, although upon examination of the microstructure a slight reduction in the amount of carbides and a beginning of ferrite formation around the graphite flakes in the heat-affected zone will be noted.

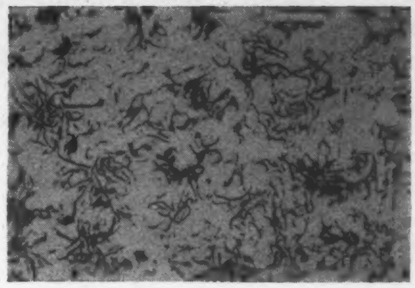
Summarizing the information on these first three ranges on gas welding, the structure and hardness has remained quite constant throughout.

Arc Welding. As might be expected, the 70° F. arc-welded specimen shows a considerably higher hardness range than the corresponding gas-welded specimen (Fig. 5). Again, note that the weld metal with a high hardness of 370-381 Vickers is considerably harder than the heat-affected zone (315 Vickers). Turning to the microstructure, it is readily apparent that the deposited metal and the heat-affected zone are much more sensitive to the absence of preheat and postheat than were the gas-welding specimens.

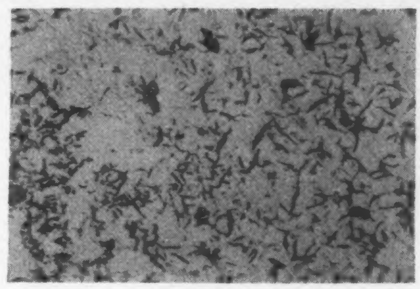
Incidentally, note the fine graphite pattern of the arc-weld metal (Fig. 5).

The weld metal shows a martensite matrix with steadite areas tending to form a network. The heat-affected zone shows a mixture of medium pearlite and platelike martensite and small carbide areas. The parent metal shows a pearlitic matrix, as in the gas-welded specimens.

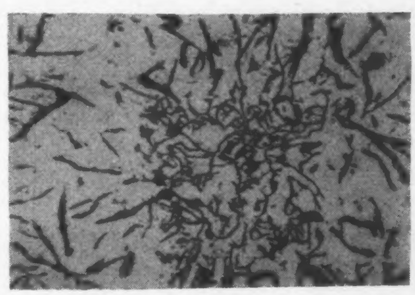
At a 500° F. preheat and postheat an appreciable reduction in the weld metal hardness is noted (Fig. 6), but not much change in the heat-affected zone. Again the weld metal shows a martensite matrix with a steadite network, and the



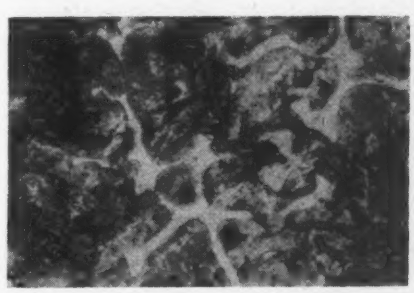
Parent metal. 100X



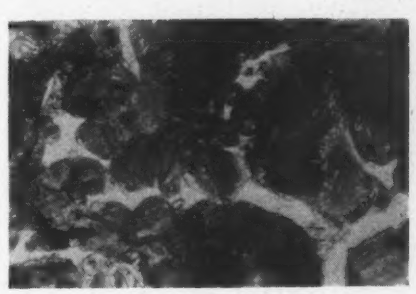
Weld. 100X



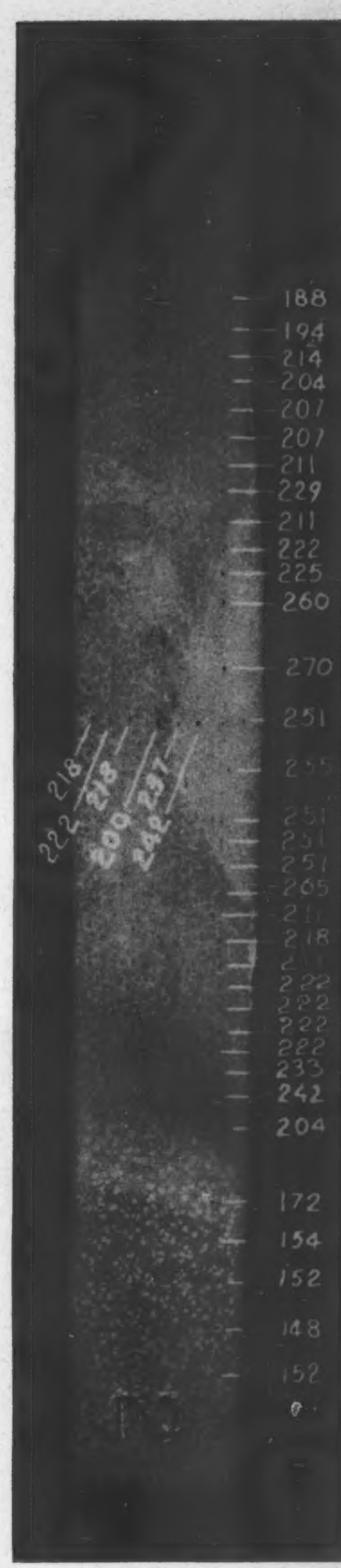
Heat-affected zone. 100X



Weld. 500X



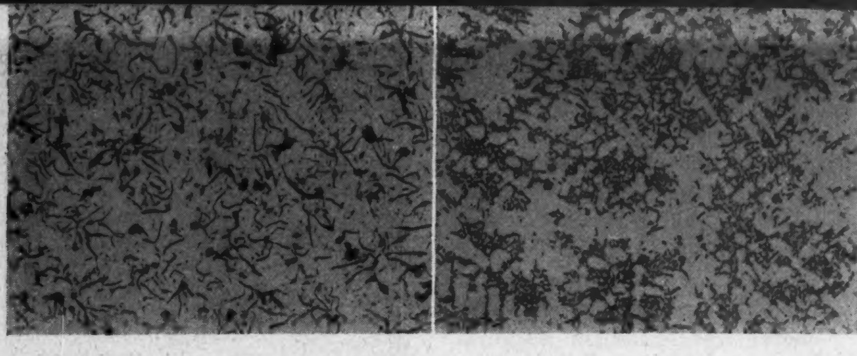
Heat-affected zone (nital etch). 500X



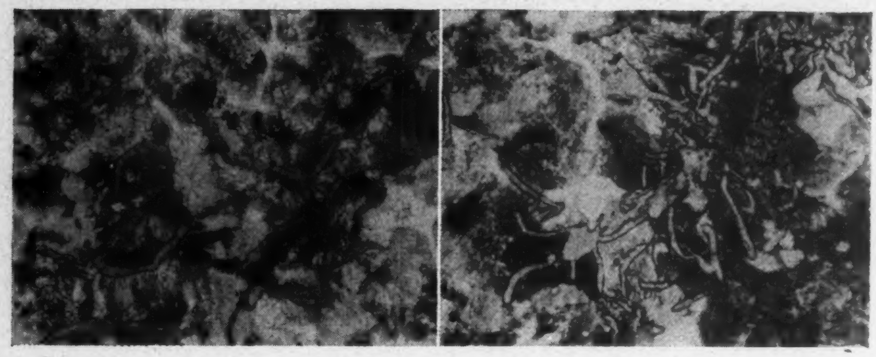
Macrosection. Vickers Brinell (10 kg.).

Fig. 2—Gas-weld specimen with rod No. 2 at room temperature showing similarity of structure and hardness with the same condition.

Macrosection. Vickers Brinell (10 kg.).



Weld. 100X Heat-affected zone. 100X



Weld (nital etch). 500X Heat-affected zone (nital etch). 500X

Fig. 3—This gas weld, made with 500° F. preheat and postheat, shows a similar hardness range and microstructure to those welded at room temperature.

Macrosection. Vickers Brinell (10 kg.).

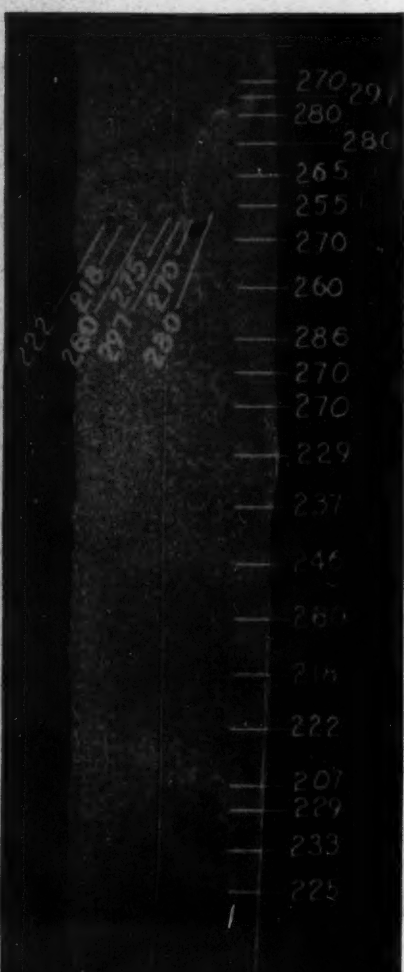
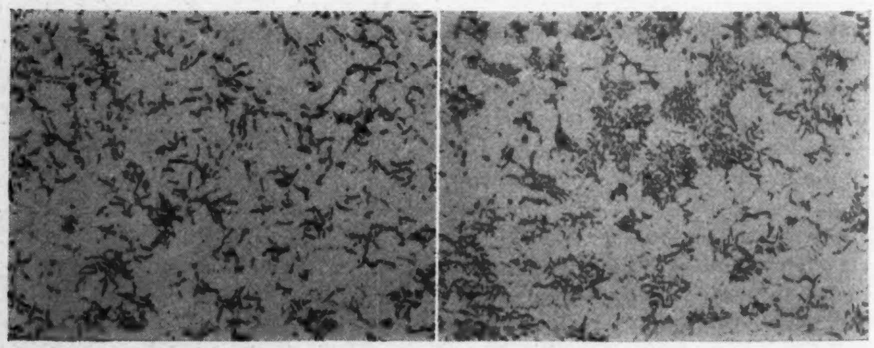
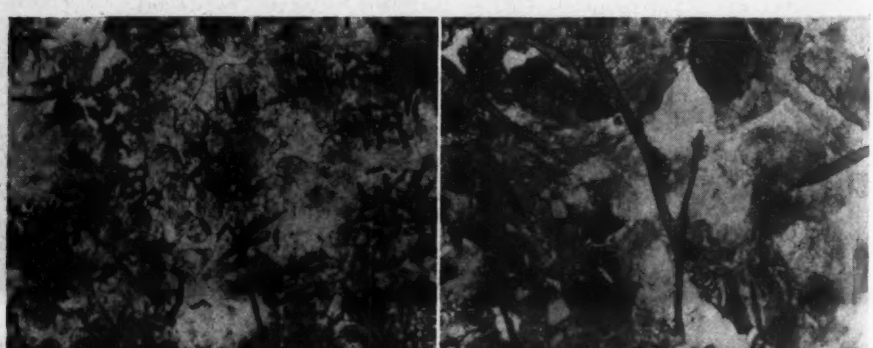


Fig. 4—The gas weld with 1000° F. preheat and postheat again shows a hardness and structure similar to Figs. 1, 2 and 3, but note a slight decrease in carbides together with an indication of ferrite formation around the graphite flakes.

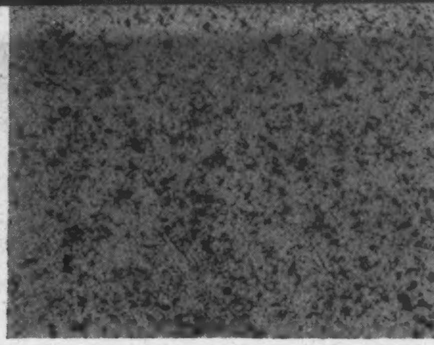
Weld. 100X Heat-affected zone. 100X



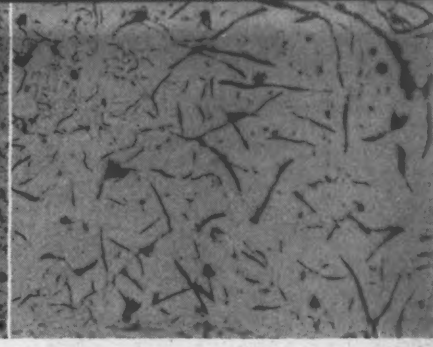
Weld (nital etch). 500X Heat-affected zone (nital etch). 500X



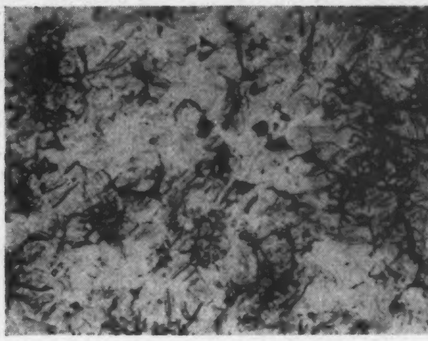
Macrosection. Vickers Brinell (10 kg.).



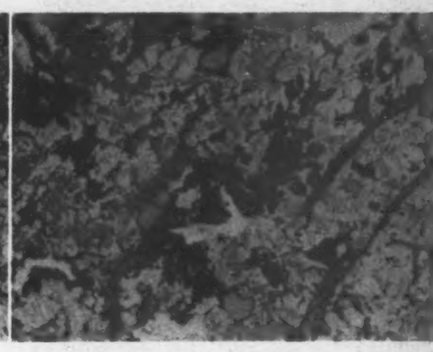
Weld. 100X



Heat-affected zone. 100X



Weld (nital etch). 500X



Heat-affected zone (nital etch). 500X

Fig. 5—Arc weld with cast iron electrode welded at room temperature. Note high hardness and martensitic structure in weld and heat-affected zone.

Macrosection. Vickers Brinell (10 kg.).

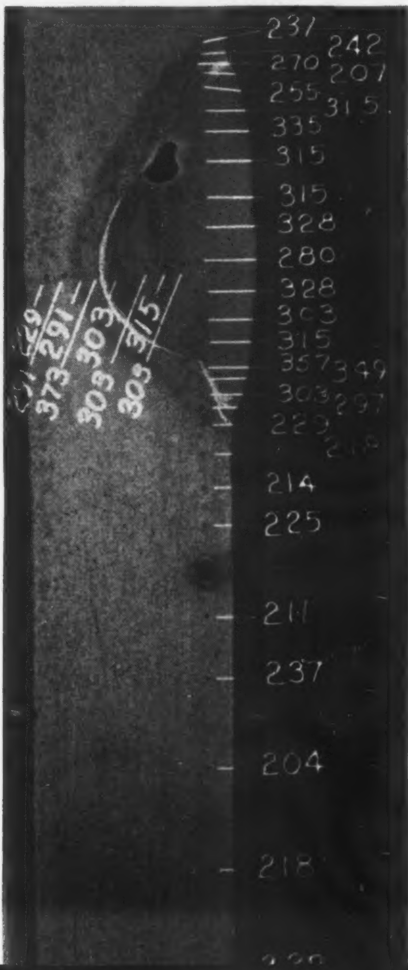
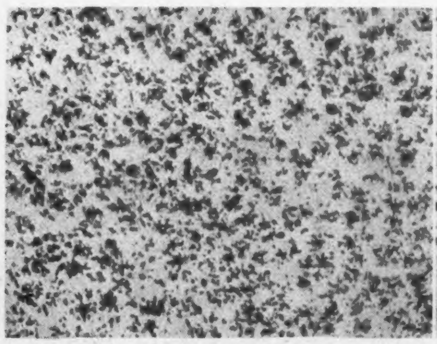
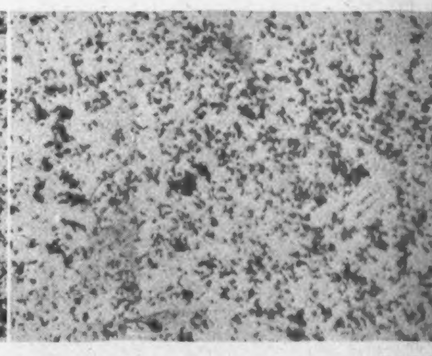


Fig. 6—The arc-welded specimen with 500° F. preheat and postheat, while showing some improvement in weld hardness still has a martensitic matrix in weld and coarse acicular structure in heat-affected zone.

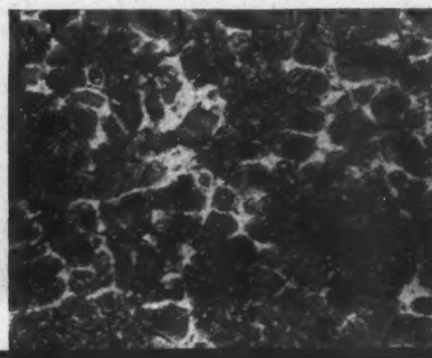
Weld. 100X



Heat-affected zone. 100X

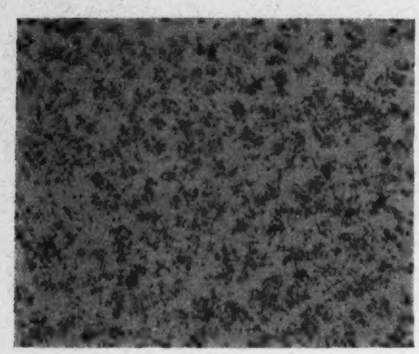


Weld (nital etch). 500X



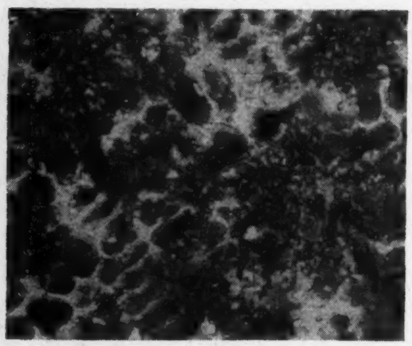
Heat-affected zone (nital etch). 500X

Macrosection. Vickers Brinell (10 kg.).

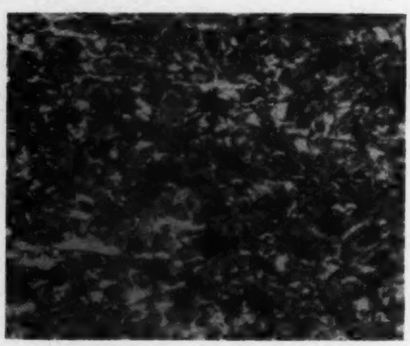


Weld. 100X

Heat-affected zone. 100X



Weld (nital etch). 500X



Heat-affected zone (nital etch). 500X

Fig. 7—When arc welded at 1000° F., hardness of the weld and heat-affected zone is definitely reduced and the structure shows a change from a martensitic to a sorbitic matrix.

heat-affected zone shows a coarse acicular structure with some steadite and carbides present.

The 1000° F. preheat and postheat arc-welded specimen shows a better condition in hardness traverse (Fig. 7) than the other previously discussed arc-welded specimens. Although averaging about 40 points Vickers higher than the comparable gas-welded specimen (Fig. 4), it now has an appearance more closely agreeing with the gas-welded condition.

Upon examination of the microstructure, it will be noted in both the weld metal and heat-affected zone the martensitic matrix has been replaced by a sorbitic structure, but with the steadite network still present in the weld metal and carbides in both weld metal and heat-affected zone. This steadite network in the arc-weld metal undoubtedly is due to the high phosphorus of this electrode. It will also be noted that in the heat-affected zone are the beginnings of ferrite formations around the graphite flakes.

Due to the small size of the specimens, the conditions noted for the arc-welded technique might be more nearly representative of conditions found on large castings than the gas-welded specimens since some preheat and postheat effect occurred during gas welding. The structures for the arc-welded specimens, both at 70° F. and 500° F. are too hard for good machinability and are not desirable from a strength standpoint.

While the hardnesses of the best of these specimens are still somewhat higher than those usually associated with good machining practice, no machining difficulties have been reported from the authors' production machine shops, although a large number of such repairs have been machined in the past.

Arc and Gas welding with 1400° F. Preheat. Studying the conditions of both arc- and gas-welded specimens which were subjected to 1400° F. preheat and postheat, it will be noted that the hardness range dropped severely not only in the weld and heat-affected zone but also in the parent metal, and that the heat-affected zone as such is practically eliminated (Fig. 8). This indicates that in spite of lower and more desirable hardnesses some structural change has taken place

throughout the test specimen.

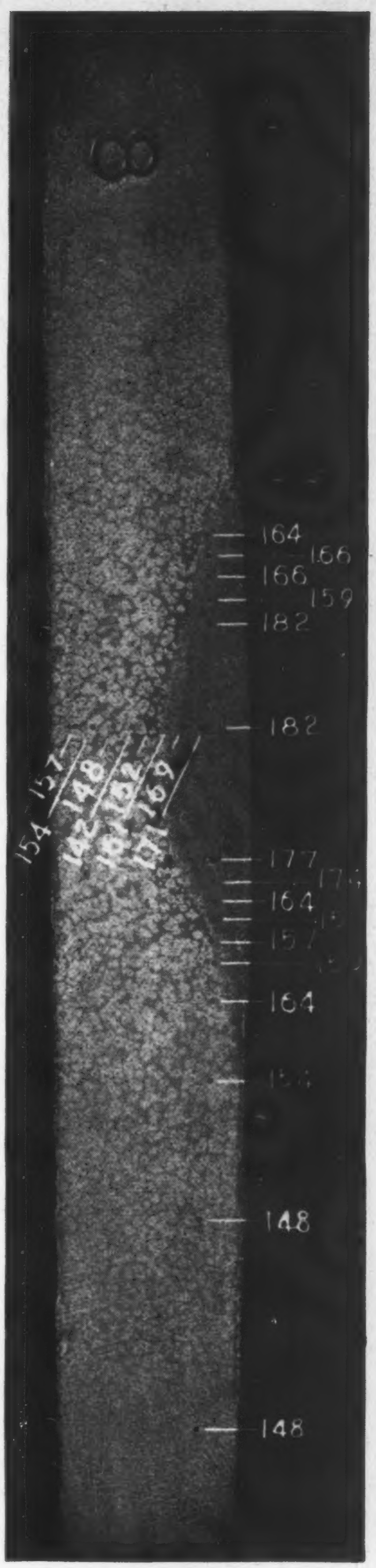
Microstructure of the gas specimen shows (Fig. 9) a ferrite matrix with some coarse pearlite near the graphite flakes and the continued presence of steadites and carbides. In the case of the arc-welded specimen, the ferrite matrix again is present, as well as the steadite network in the weld metal. The heat-affected zone showed a ferrite structure with small amounts of pearlite and some carbides. The parent metal in both cases showed a ferrite matrix with some areas of pearlite.

The dissimilarity between the two types of welding with this heat treatment is small, and in neither case is the structure obtained desirable. Obviously, the amount of combined carbon in these structures is low and the iron involved would have poor strength characteristics. Furthermore, these heat treatments which were held to minimum time length would be much shorter in duration than those which might be expected on a complete casting, and therefore this transformation on large castings would be even more complete.

Reviewing the trends in these studies, the gas welding conditions found at 70° F., 500° F. and 1000° F., all showed a reasonably desirable structure and hardness range without much apparent difference between the various heat treatments. However, at 1000° F., the beginnings of ferrite formation around the graphite flakes and the tendency toward reduction in the amount of carbides present apparently resulted from a slower rate of cooling from temperatures above 1200° F. brought about by the higher preheat and postheat.

This also indicates that even at this temperature the pearlite is beginning to break down into ferrite, which tendency effected a complete change-over at 1400° F. While a more desirable machining hardness might be obtained by a higher preheat and postheat, reduction in combined carbon would have to be watched closely in this range between 1000° F. and 1400° F. so that the damage would not more than offset the advantage.

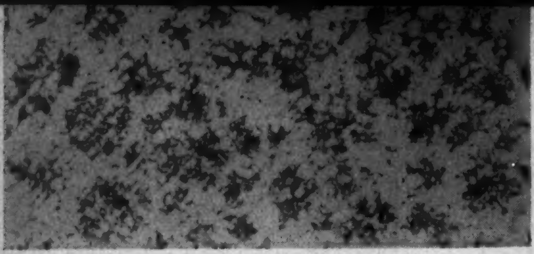
Of course, the change in the rate of cooling was much more pronounced in the case of the arc welding where preheats and postheats in excess of 500° F. are indicated in



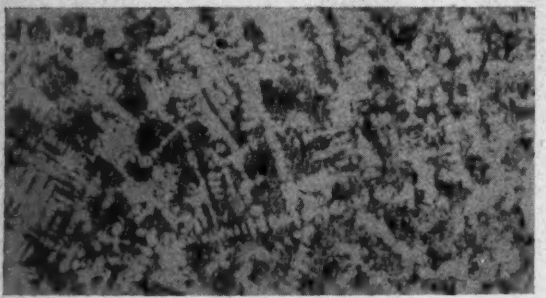
Gas-welded specimen.

Arc-welded specimen.

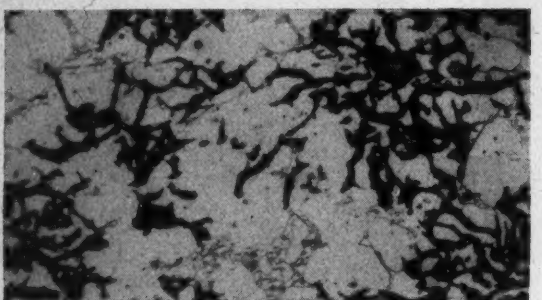
Fig. 8—Note that low hardness is found on both arc- and gas-welded specimens with 1400° F. preheat and postheat, not only in weld and heat-affected zone but also in parent metal.



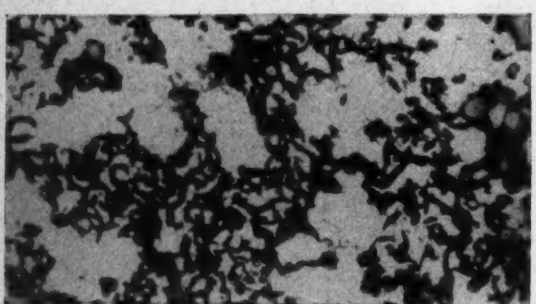
Weld. 100X



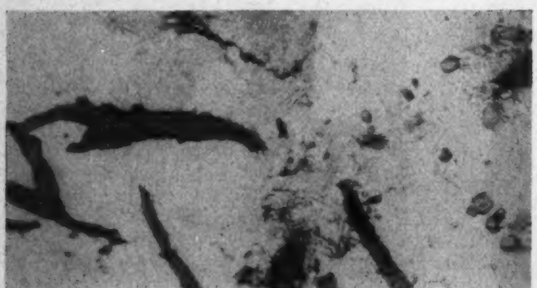
Heat-affected zone. 100X



Weld. 500X



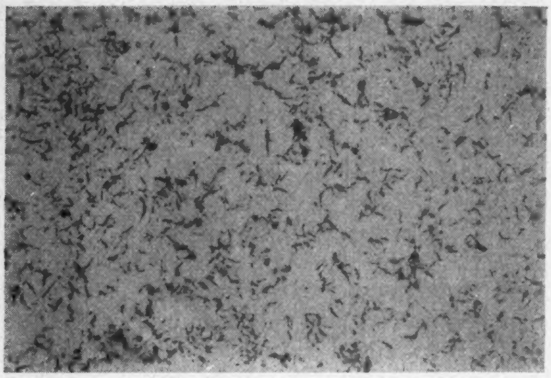
Heat-affected zone (nital etch). 500X



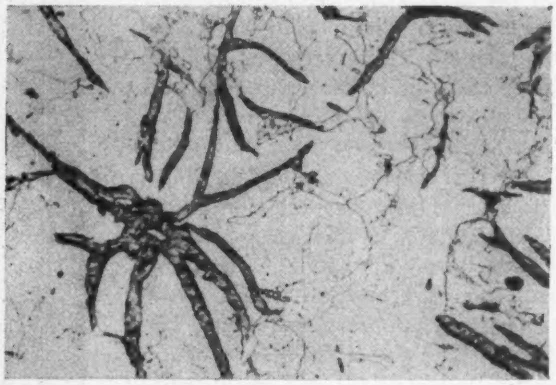
Parent metal (nital etch). 500X

Arc-welded specimens.

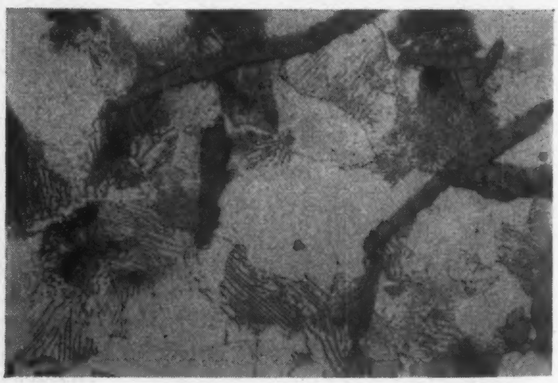
Weld. 100X



Heat-affected zone. 100X



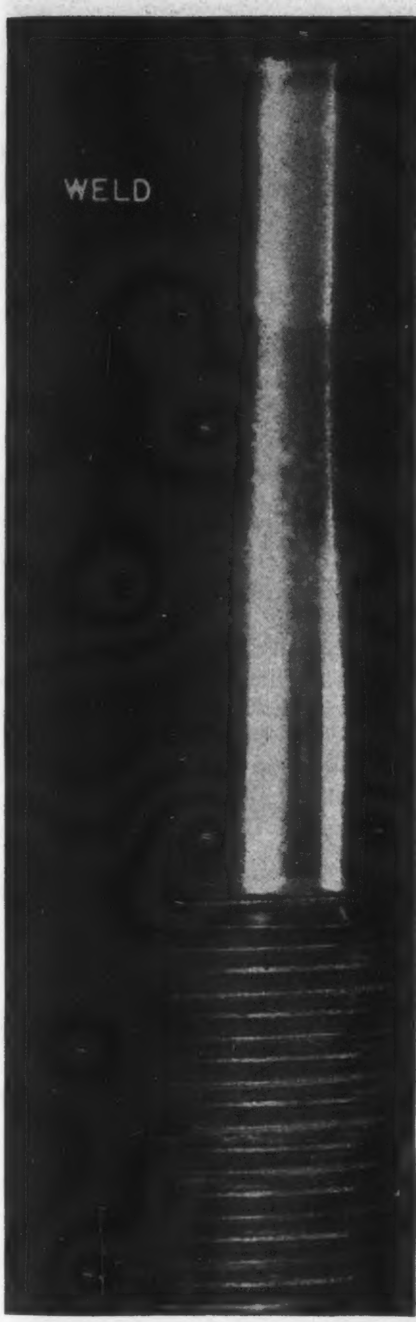
Weld (nital etch). 500X



Heat-affected zone (nital etch). 500X

Gas-welded specimens.

Fig. 9—The structure of these welded specimens with 1400° F. preheat and postheat shows a ferrite matrix in heat-affected zone and parent metal, although steadite and carbides are still present. Low combined carbon.



Specimen (1)
Gas Weld
27,500 psi.
GM 13M Iron

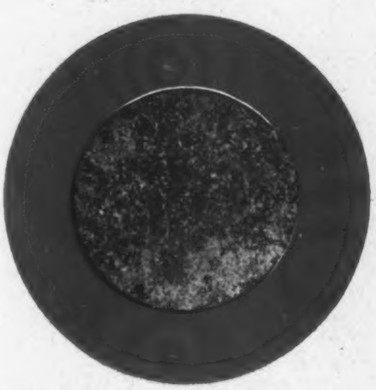
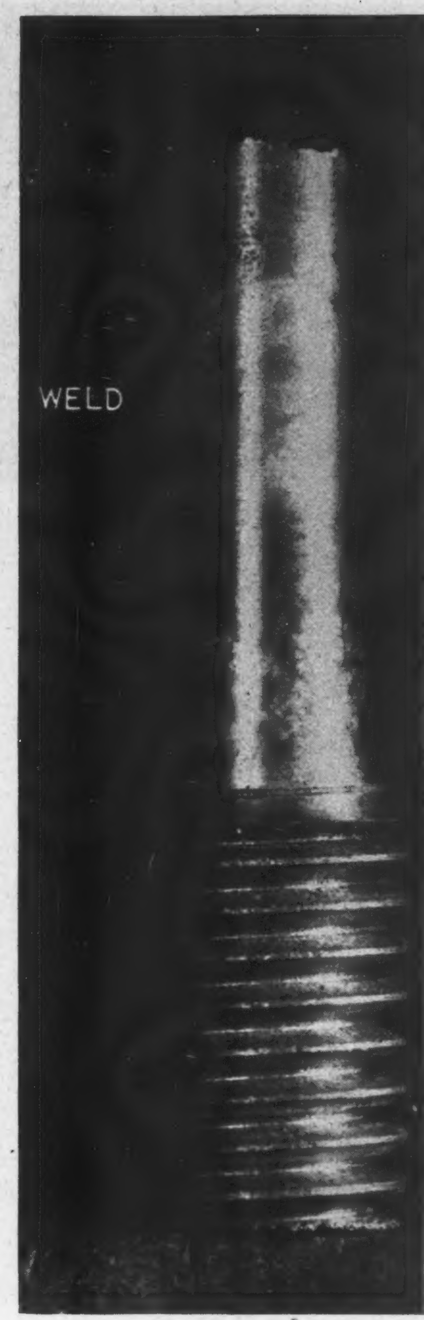


Fig. 10—Gas-weld specimen (type No. 1 rod) highly etched to show weld location.



Specimen (2)
Gas Weld
29,000 psi.
GM 13M Iron

Fig. 11—Gas-weld specimen (type No. 2 rod) showing failure outside weld.

Specimen (4)
Arc Weld
26,000 psi.
GM 13M Iron

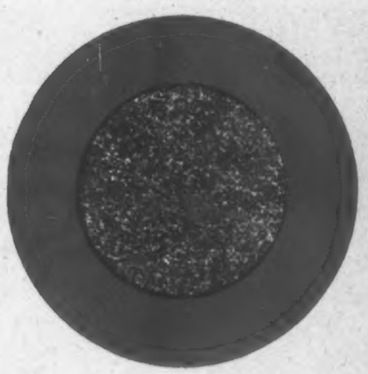
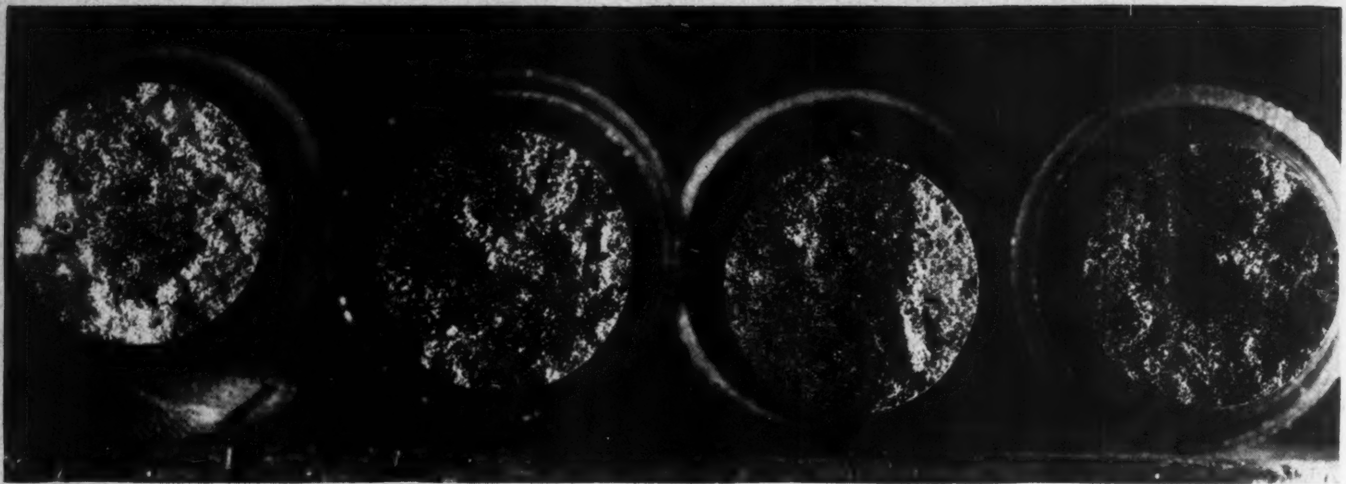


Fig. 12—Arc-welded specimen with 1000° F. preheat and postheat showing failure well outside of weld.



order to obtain a desirable structure for either machining or strength characteristics. While the arc welding is indicated as a more limited process, its advantage of much greater production speed should not be overlooked.

Physical Properties. The gas-welded 0.505 in. tensile bars made represented the first condition outlined in the foregoing, that is, with only local preheat and postheat. However, the arc-welded specimen was welded with a 1000° F. preheat and postheat, as arc welding at room temperature was felt to be too severe to offer practical information. The tensile strengths of the gas-welded specimens at 27,500 psi. (Fig. 10) and 29,000 psi. (Fig. 11) were somewhat higher than that of the arc-welded specimen at 26,000 psi. (Fig. 12).

However, it will be noted that

Fig. 13—Comparison of the type of fractures of the four 0.505-in. bars. No. 3 is the parent metal specimen (38,500 psi.).

all specimens broke outside the weld and in the heat-affected zone, indicating possibly that the general preheat and postheat might have weakened the heat-affected structure somewhat. Comparison with the base metal strength of 38,500 psi. (Fig. 13) indicates that the heat-affected zones have been reduced in strength about one-third. Since these welds were made in as nearly a production manner as possible and then x-rayed for soundness, they are believed to be fairly representative of what might be expected under production conditions.

Therefore, in the use of welding, the strength of the heat-affected zone and not the weld should be considered. All of this indicates that a strength factor of two-thirds of casting strength should be used in considering these welding processes.

Nickel Welding. During the study of this type of welding it was found that the different methods of application were equally different in the results obtained. Welding with

Fig. 15—The weld made with the copper-sheathed nickel without coating shows a narrow heat-affected zone, but also hard. This can be controlled to some extent by varying procedure.

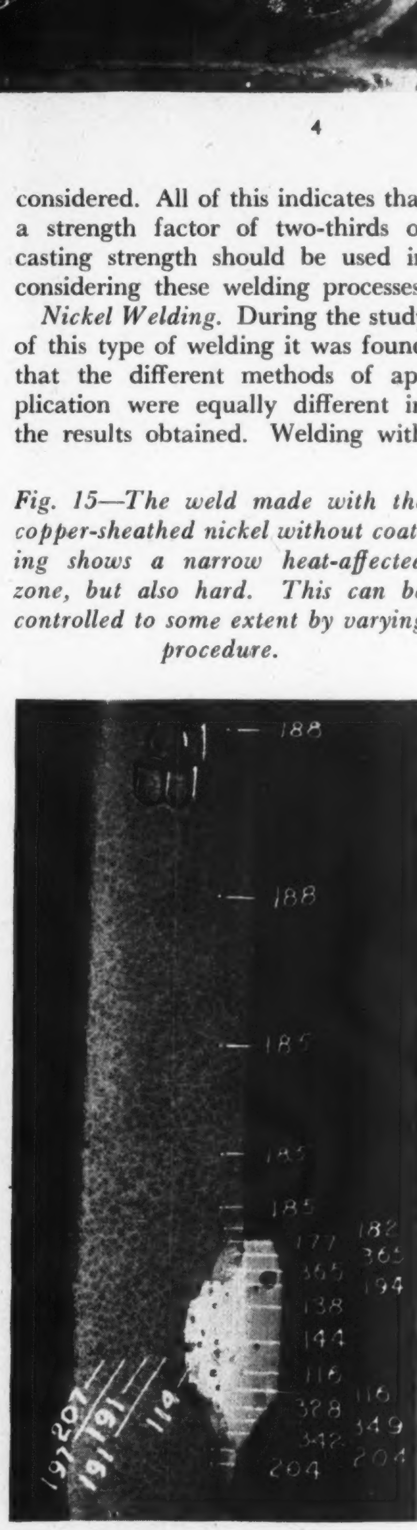


Fig. 14—Typical microstructure of cold (bare nickel) welding showing penetration of the nickel into the iron. 100X (left) and 500X (right).

the bare nickel electrode with the low-voltage high-current technique (commonly called bore and cold welding) gave almost no perceptible heat-affected zone.

In fact, while the technique would indicate that only a mechanical bond is obtained, this is not true as there does seem to be a penetration of the nickel right into the cast iron base metal (Fig. 14). Of course, this technique is practical only for small flaws, but when applied with reasonable skill should give highly desirable results.

Welding with the copper-sheathed nickel electrode gives a more apparent heat-affected zone, although narrow, and is done in a more conventional manner. Again, good fusion is in evidence, but localized high hardnesses are observed (Fig. 15).

The coated electrode welding has the penetration and fusion characteristics of standard mild-steel electrodes. This is true of both the nickel-core electrode as well as the monel-core electrode. (Fig. 16). It will be noted that both of these deposits have much the same appearance and the same heat-affected zone characteristics (hardness, range, etc.). The microsection of the heat-affected zone (Fig. 17)

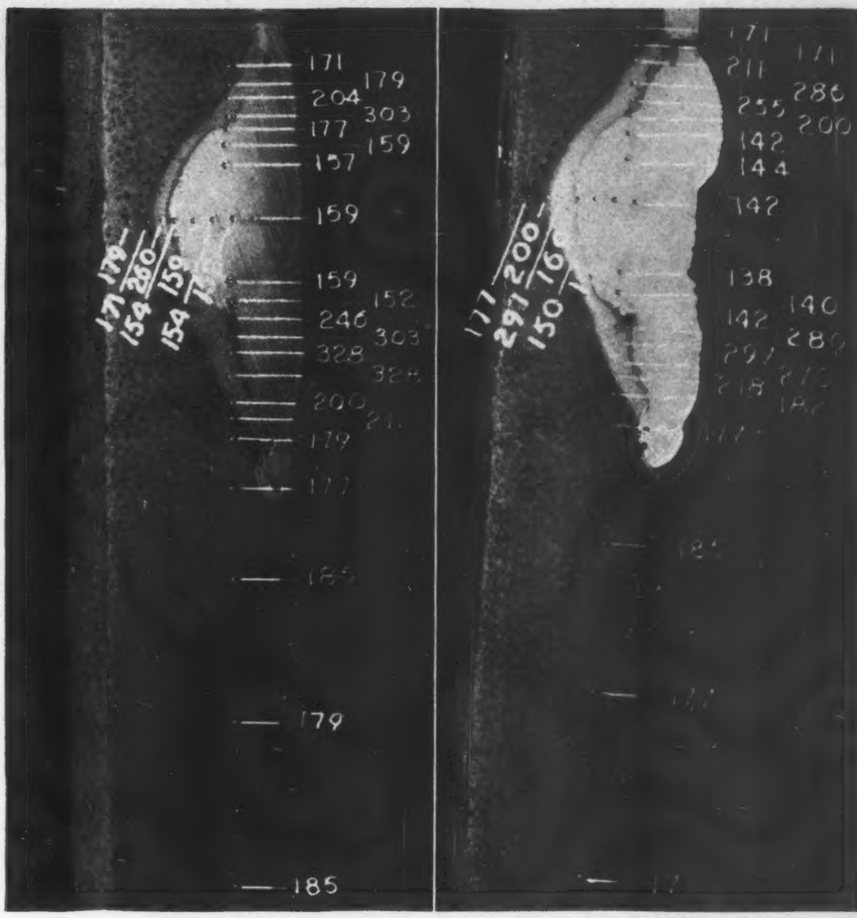
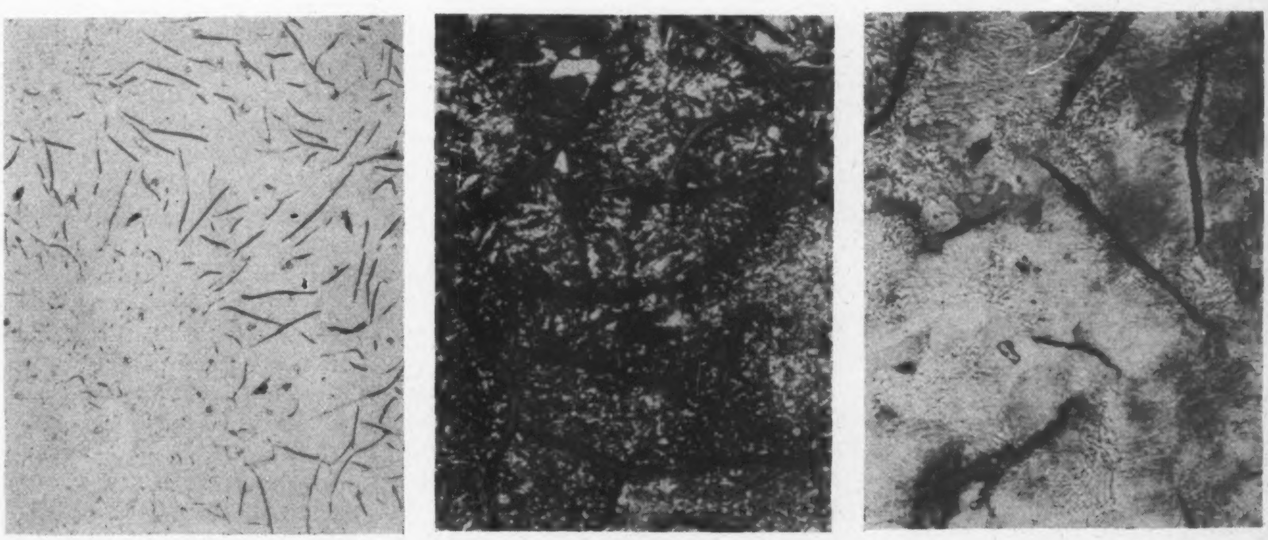


Fig. 16—Comparison of the coated nickel (right) and monel (left) electrode deposits show a close similarity between the extent and hardness of the heat-affected zones, although the weld metals etch differently.



Heat-affected zone. 100X **Heat-affected zone (nital etch). 500X** **Parent metal (nital etch). 500X**

Fig. 17—The transition from martensite to sorbite matrix in the heat-affected zone shows the sudden change in structure that can be expected with monel or nickel coated electrode.

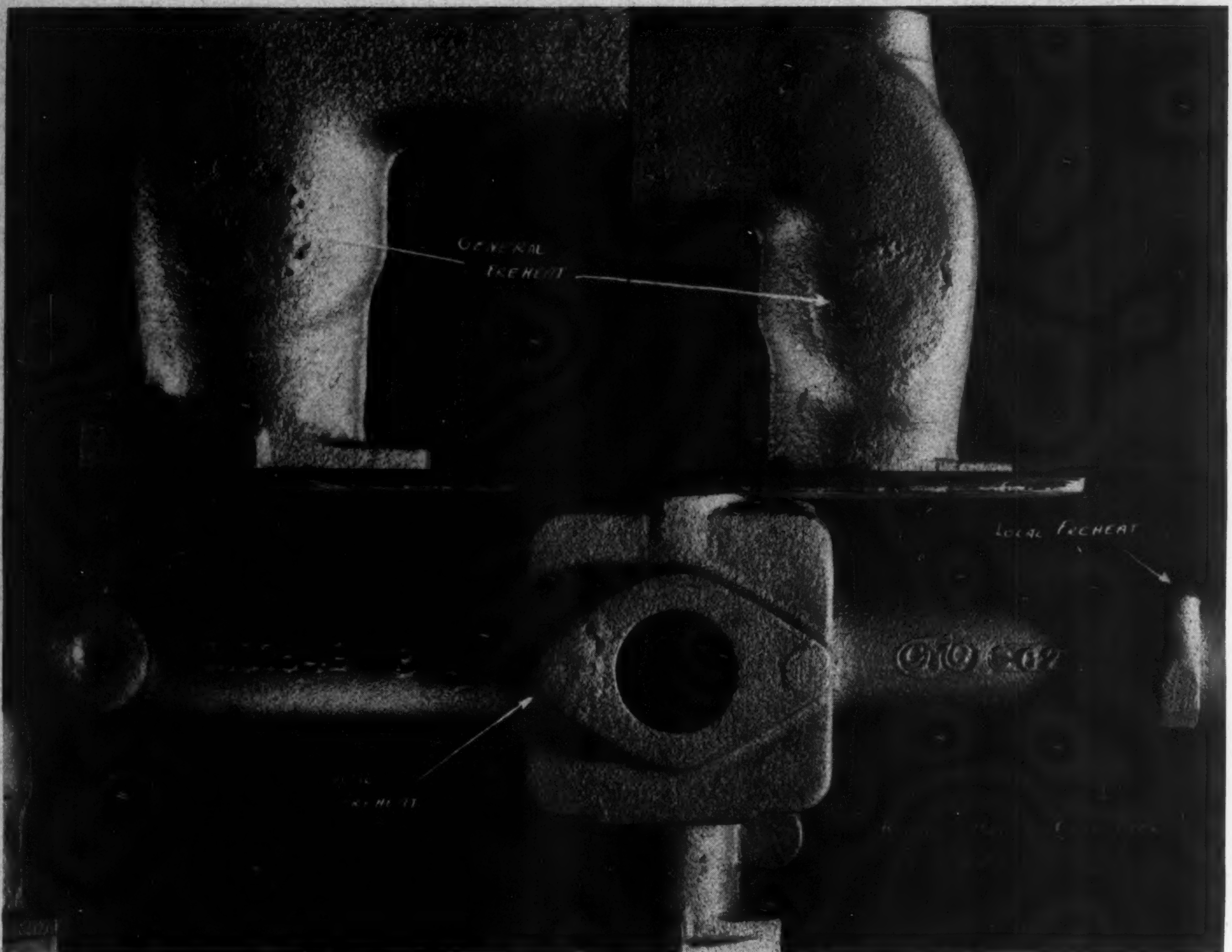


Fig. 18—Sectional views of one of the intake manifolds with arrows and notes pointing out the gas-weld repairs and the type of preheat and postheat.

shows a martensitic structure not unlike that found in the cast iron arc-welded deposit.

However, both the bare and coated monel, as well as the nickel, have lower maximum hardness ranges in the heat-affected zone than the cast iron arc-welded material, even though the parent metal was at the same temperature and condition at the start of welding. This probably is due to the higher amperage required for the cast iron material (170 amp.) as compared to the rather low amperage used with the nickel and monel materials (80 amp.).

Table 2
COMPOSITION OF GAS-WELDED HIGH-SULPHUR CAST IRON

Element	*Bar, per cent*	*Weld, per cent*
Total Carbon	3.63	
Graphitic Carbon	2.78	
Combined Carbon	0.85	
Manganese	0.54	
Phosphorus	0.11	0.32 *
Sulphur	0.27	0.091*
Silicon	2.60	2.70 *
Nickel	0.19	
Chromium	0.14	
Molybdenum	0.02	
Copper	0.10	
Vanadium	0.05	

*The elements only checked on weld.

Softness of the deposited metal, plus the relatively low heat-affected zone hardness, indicates that this process should be satisfactory for areas to be subsequently machined. Although ordinarily used only for small flaws, the strength of the joint again was found to be a function of the heat-affected zone, and therefore should approximate the tensile properties shown for the cast iron filler metal.

High Sulphur Cast Iron. During the war, the subject of the effect of sulphur content in the cast iron was brought up repeatedly. One of the criticisms of high sulphur was that it impaired the weldability of the cast iron. A study was made of some gray iron castings in which excess sulphur was added in the ladle.

Two manifold castings were made from a production pattern, and gas-weld repairs were made under normal conditions (Fig. 18). A 0.505-in. bar was made from a welded piece of runner stock from the same iron (Fig. 19). Chemical composition of this material is shown in Table 2.

Macrosection of one of the repaired flanges is shown in Fig. 20 with hardness range. Although this weld was done with local preheat and postheat, it will be noted that the hardnesses are moderate except in the deposited weld metal itself. No indication of porosity can be seen, or of abnormal structure of greater magnitude than that usually found in this type of repair. Aside

from a pronounced sulphur odor during welding, no difference was noted in welding on this material.

While the 0.505-in. tensile bar showed a somewhat lower ultimate strength than those previously listed, the type of failure was the same and the results are considered within possible variation of the process and parent metal. Even though the sulphur content was considerably above permissible Navy specification limits, both castings and welds were found sound.

Conclusions

Gas Welding. Preheat and postheat treatments serve the primary function of minimizing thermal stresses in the casting and not necessarily simplification of the welding technique. Therefore, welding done on areas without potential locked-up stresses needs only local preheat and postheat with the torch in order to minimize effects of local thermal gradients. Even with the local heat treatment, the maximum hardnesses found were in the weld metal, which remained quite constant throughout test, until the preheat and postheat temperatures of 1400° F. were used.

This process gives physical properties with tensile strength 70 per cent of that of the unaffected parent metal. The heat-affected zone is the critical area, and does not seem to be materially improved by the preheat and postheat treatment. Therefore, weld failures on repaired castings indicate stresses in the welded areas in excess of this 70 per cent factor. Sulphur content up to 0.27 per cent gave no noticeable effect on the casting or its weldability.

Arc Welding. In order to minimize the much sharper thermal gradients found with this process, 1000° F. preheat and postheat treatment is necessary if the hardness range of the weld and heat-affected zone is to be kept within reasonable limits. However, the soundness of the weld and its physical properties appear equally as good as those obtained by the gas-welding process. As the speed of welding is much faster with the arc process (and the electrode has good operation characteristics), this process should come into increasing favor.

Cast Iron Filler Metal Processes. Preheat and postheat treatment in excess of 1000° F. is potentially harmful to the casting even with

Fig. 19—High sulphur gray cast iron 0.505 in. diameter tensile bar. Tensile strength, 20,000 psi.

Failure in heat-affected zone and weld.

No perceptible flaws in failure.

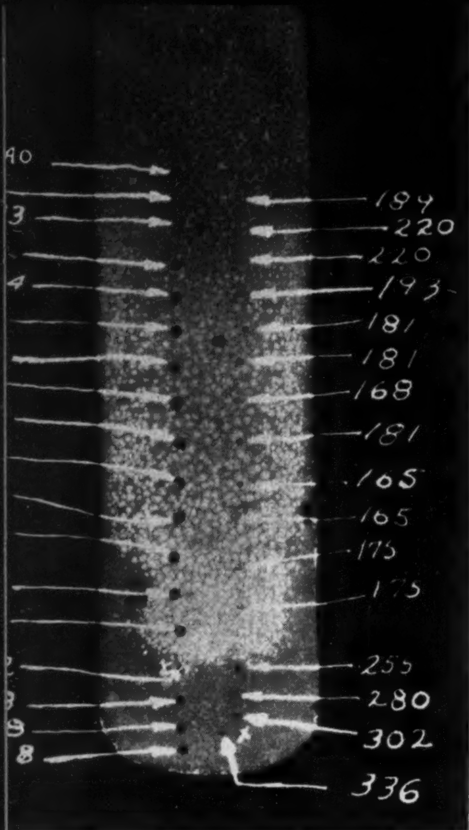


Fig. 20—Although only locally preheated and postheated (see Fig. 18), the hardnesses and structure of this gas weld on high-sulphur iron seem normal.

short heat treatment cycles. Even at 1000° F. some evidence of ferrite formation is apparent around the graphite flakes, which at 1400° F. has grown into a ferrite matrix. The nature of the structure at 1400° F. indicates a low amount of combined carbon, and the resultant structure is weak and not nearly as desirable for the end use of most gray iron castings, even though the heat-affected zone was almost entirely eliminated at this heat.

Nickel Welding. Both nickel and monel materials indicate good results for small flaws, with varying amounts of heat-affected zone with the different techniques. Cold welding showed no appreciable heat-affected zone, while the coated electrodes gave zones similar to the cast iron filler metal in the arc process.

Using Coated Electrodes

However, in the case of the coated electrodes, the heat-affected zone was found to be much lower in hardness than with the cast iron process, and this is attributed to the lower electrical energy input during welding. This factor indicates that the practice of making short weld segments and cooling before continuing welding is sound, both from the heat input standpoint and that of minimizing thermal stresses.

The bare nickel shows a peculiar affinity for cast iron even though arc welding in the true sense is not accomplished. All of the deposited metals in this class are soft and suitable for machining. Intermittent welding results checked seem to be equally good, but have a greater tendency toward porosity.

1. Both gas and arc cast iron filler metals produce structures or assemblies having two-thirds the ultimate strength of the parent material.

2. These physical characteristics can be expanded in the future to make practical fabrication of cast iron weldments.

3. Cast iron arc welding is equally as good as gas welding under proper conditions, and is advantageous because of its higher production speed.

4. Excessive preheat and postheat treatments often are more harmful than no treatment at all.

5. The peculiar affinity of nickel for iron makes possible the elimination of the heat-affected zone in repairing small flaws. Both monel and nickel offer satisfactory material for repairing without the use of preheat and postheat.

6. The sulphur content of the iron when less than 0.27 per cent is not considered a factor in weldability.

7. All of the foregoing methods investigated have a useful place, and if studied and properly controlled will do much to minimize foundry scrap and expedite production.

The authors wish to gratefully acknowledge the help of R. C. Nelson, Walter Zeller, and E. O. Falberg of GMC Truck & Coach Div., and of S. M. Lenhoff and J. P. Thomas of Detroit Diesel Div., of General Motors, in the preparation of this paper.

Ordnance Foundryman Herman E. Alex Dies

HERMAN E. ALEX, general foreman, foundry, pattern and woodworking departments, Rock Island Arsenal, Rock Island, Ill., died suddenly July 10 at his home in Davenport, Iowa.

Mr. Alex held the longest service record of any ordnance employee in the country, having joined the Arsenal in 1892 as a molder. He was awarded Honorary Life Membership by the American Foundrymen's Association at its Annual Convention in Buffalo, in 1944, in recognition of his valuable services to the foundry industry during a career which, at that time, had extended over 55 years.

Herman Alex

Following attendance at local schools in Davenport, where he was born, he joined the Davenport Machine & Foundry Co., of that city, in 1889, remaining with the firm until he moved to the Arsenal. He advanced to the position of general foreman in 1911, and served in that capacity until his death. He was 73 years old.

Always interested in foundry associations, Mr. Alex was a charter member of the Quad-City Foundrymen's Association, which became the Quad-City chapter of A.F.A. in 1935; and he served as Chapter Chairman for the 1939-40 chapter season.

A SIMPLE COST SYSTEM

FOR SMALL FOUNDRIES

R. L. Lee
Comptroller
Grede Foundries, Inc.
Milwaukee

DURING THE PAST SEVERAL YEARS an increasing demand has appeared for the formulation of a simple cost estimating system that would enable operators of a small foundry to make more accurate cost estimates, check actual costs against estimated costs, and to do so with a minimum of accounting personnel. Obviously, any cost set-up which would require the hiring of several additional employees would not fit in with the payroll requirements of a minimum size plant.

The cost estimating system outlined in this article is one that can be installed with little or no extra clerical help, and involves a minimum cost for printing or mimeographing of necessary forms. It should be pointed out, however, that this "system" is intended only for the purpose of cost estimating. The various foundry trade associations have published detailed cost systems for all branches of the foundry industry, and this work has enabled many foundries throughout the country to determine their operating costs with a high degree of accuracy.

In general, the estimating system outlined here follows those methods employed in most of the published cost systems, one exception being the method of estimating cleaning costs. Here the author has used a percentage of mold and core direct labor, a method based on his experience with foundry work extending over a considerable period of years, and it is realized that this method may be in conflict with some of the cost systems advanced by other groups and utilized in many parts of the country.

It is believed, however, that the average small foundry should find well adapted to its purpose the suggested use of mold and core direct labor in estimating its cleaning costs.

No additional help will be required and no additional work is entailed other than a few hours spent in arranging the year's results in the manner outlined, and the time spent in making up the estimating sheets on the individual patterns.

In the payroll distribution shown on Form C, the 20 men are divided among the departments (Table 1).

Burden percentages and metal costs usually are figured after the close of the year unless there have been radical changes in material costs or method of plant operation. The percentages are used in estimating during the following year. If data for a full year are not available, do not use figures for a period of less than 3 months.

The plant is divided into four departments—Melt,

Table 1

LABOR DISTRIBUTION

Department		*Labor*
Melt		2
Molding	molders	6
	laborers	4
Core	coremakers	2
	laborer	1
Clean and ship		5*
Total		20

*Two men help shift molds in molding department.

Table 2

POWER DISTRIBUTION

Department	*Equipment*	*Motors, hp.*	*Use, hr.*	*HP. Hours*	*Percentage of Total*
Melt	Blowers	50	3	150	23.4
	Hoist	5	8	40	
Mold	Part of compressor motor	50	2	100	17.3
	Mixer	5	8	40	
Core	Mixer	5	8	40	5.0
Clean	Part of compressor motor	50	6	300	54.3
	Tumblers	15	8	120	
Total				810	100

With all indications pointing to a highly competitive industrial period just ahead, it becomes increasingly imperative that foundries should know their costs. For many years, operators of small foundries employing anywhere from 10 to 30 people have felt that an adequate cost system was beyond their means . . . that it would require several additional employees, cost money, and was "more trouble than it was worth."

Mold, Core, Clean and Ship. A simple way to arrange the year's figures for use in estimating costs is shown on Forms A and B for gray iron and non-ferrous, respectively. Form C is a form for payroll distribution. Form D—gray iron estimating sheet, and Form E—non-ferrous estimating sheet.

Power Distribution. It is not necessary to have separate accounts for each department; a percentage based

Form A—Gray Iron

FORM OF OPERATING STATEMENT TO ESTABLISH BURDEN RATES

Melt—10,000 lb. pig iron	@...............		$...............
10,000 lb. gray iron scrap	@...............		$...............
10,000 lb. steel scrap	@...............		$...............
30,000 lb.			
5,000 lb. shrinkage			
25,000 lb. net production			$...............

Metals used	100.00		
Melting labor	100.00		
Melting fuel and power	100.00		
Supplies and misc. expense	100.00		
Compensation, insurance, social security and unemployment	100.00		
Depreciation	100.00		
Analyses and tests	100.00		
Prop. general and fixed overhead ....%	100.00		
Cost of molten metal		800.00	Cost per lb. ....
Direct molding labor		100.00	
Indirect molding labor and supervision (if any)	100.00		
Supplies and expense	100.00		
Fuel and power	100.00		
Compensation, insurance, social security and unemployment	100.00		
Depreciation	100.00		
Prop. general and fixed overhead ....%	100.00		
Total molding burden		600.00	600% of direct labor
Direct coremaking labor		100.00	
Indirect core labor and supervision (if any)	100.00		
Supplies and expense	100.00		
Fuel and power	100.00		
Compensation, insurance, social security and unemployment	100.00		
Depreciation	100.00		
Prop. general and fixed overhead ....%	100.00		
Total coremaking burden		600.00	600% of direct labor
Total clean and ship labor	100.00		
Supplies and expense	100.00		
Fuel and power	100.00		
Compensation, insurance, social security and unemployment	100.00		
Depreciation	100.00		
Prop. general and fixed overhead ....%	100.00		
Total clean and ship burden		600.00	300% of direct mold and core labor

NOTE: All figures shown are purely for illustration purposes.

Form B—Non-Ferrous

FORM OF OPERATING STATEMENT TO ESTABLISH BURDEN RATES

Metals				
Our alloy	1,000 lb.	@ .10	100.00	
Copper	1,000 lb.	@ .10	100.00	
Tin	1,000 lb.	@ .10	100.00	
Lead	1,000 lb.	@ .10	100.00	
Zinc	1,000 lb.	@ .10	100.00	
Phosphorus	1,000 lb.	@ .10	100.00	
Nickel	1,000 lb.	@ .10	100.00	
Total metal charged	7,000 lb.		700.00	
Shrinkage	1,000 lb.			
Net production	6,000 lb.		700.00	*Cost per lb. ....

Melting labor	100.00		
Melting fuel and power	100.00		
Supplies and misc. expense	100.00		
Compensation, insurance, social security and unemployment	100.00		
Depreciation	100.00		
Analyses and tests	100.00		
Prop. general and fixed overhead ....%	100.00		
Total conversion cost		700.00	Cost per lb. ....
Direct molding labor	100.00	100.00	
Indirect molding labor and supervision (if any)	100.00		
Supplies and expense	100.00		
Fuel and power	100.00		
Compensation, insurance, social security and unemployment	100.00		
Depreciation	100.00		
Prop. general and fixed overhead ....%	100.00		
Total molding burden		600.00	600% of direct labor
Direct coremaking labor		100.00	
Indirect core labor and supervision (if any)	100.00		
Supplies and expense	100.00		
Fuel and power	100.00		
Compensation, insurance, social security and unemployment	100.00		
Depreciation	100.00		
Prop. general and fixed overhead ....%	100.00		
Total coremaking burden		600.00	600% of direct labor
Total clean and ship labor	100.00		
Supplies and expense	100.00		
Fuel and power	100.00		
Compensation, insurance, social security and unemployment	100.00		
Depreciation	100.00		
Prop. general and fixed overhead ....%	100.00		
Total clean and ship burden		600.00	300% of direct mold and core labor

*Cost per lb. will vary for different mixtures.
NOTE: All figures shown are purely for illustration purposes.

on horse-power hours can be charged when making an operating statement on Form A or Form B (Table 2).

Depreciation: buildings on the basis of floor space occupied by each department; machinery and equipment on the basis of actual value used in each department.

Compensation Insurance, Social Security, and Unemployment Insurance: on basis of ratio of total departmental payroll (direct, indirect, and supervision, if any) to total payroll.

General and Fixed Overhead. Items chargeable to these accounts include: General salaries and clerical (including a fair salary for the proprietor and his wife, if she is bookkeeper, even if not charged on books); all taxes except payroll, income and sales tax; heat; interest (including interest on investment at 6 per cent, even if not charged on books); other general expenses.

Distribute general and fixed overhead to the four departments on the basis of percentage of total payroll or judgment. An arbitrary distribution, giving weight to time spent in supervision, etc., in general use is melt 8 per cent, mold 43 per cent, core 25 per cent, and clean and ship 24 per cent.

After these items and charges have been established, arrange an operating statement as shown in Form A for gray iron, or Form B for non-ferrous.

Estimating sheets may then be prepared for the individual castings on Form D for gray iron or Form E for non-ferrous.

Form C

PAYROLL DISTRIBUTION

(for both gray iron and non-ferrous)

WEEK ENDING.., 19.......

No.	*Total Pay*	*Melt*	*Direct Mold*	*Indirect Mold*	*Direct Core*	*Indirect Core*	*Clean and Ship*
1	40.00	40.00	—	—	—	—	—
2	40.00	40.00	—	—	—	—	—
3	40.00	—	40.00	—	—	—	—
4	40.00	—	40.00	—	—	—	—
5	40.00	—	40.00	—	—	—	—
6	40.00	—	40.00	—	—	—	—
7	40.00	—	40.00	—	—	—	—
8	40.00	—	40.00	—	—	—	—
9	40.00	—	—	40.00	—	—	—
10	40.00	—	—	40.00	—	—	—
11	40.00	—	—	40.00	—	—	—
12	40.00	—	—	40.00	—	—	—
13	40.00	—	—	—	40.00	—	—
14	40.00	—	—	—	40.00	—	—
15	40.00	—	—	—	—	40.00	—
16*	40.00	—	—	8.00	—	—	32.00
17*	40.00	—	—	8.00	—	—	32.00
18	40.00	—	—	—	—	—	40.00
19	40.00	—	—	—	—	—	40.00
20	40.00	—	—	—	—	—	40.00
Total ..	800.00	80.00	240.00	176.00	80.00	40.00	184.00

*Two men in cleaning room help shift molds. That part of time is charged to indirect mold.

Form D

GRAY IRON

Customer..Pattern Number....................

ESTIMATE OF SALES COST

Prepared by..Date Estimate........................ Date Actual..........................

Weight.......................Estimate.....................Actual.......................

Pattern Desc..............................Iron Spec...............................
Pieces per mold..........................Weight per day...........................
Weight each...............................Less ....% returns...................
Weight per mold.........................Net weight...............................
Molds ....Net pieces................................

	Estimate	*Actual*
Iron and Melt....................	....	....
Mold price	....	....
Mold burden ....%	....	....
Core price	....	....
Core burden ....%	....	....
Clean and ship ....% of direct mold and core	....	....
Extra	....	....
Extra	....	....
Extra	....	....
Total Cost	....	....
Profit ....%	....	....

Selling price each.......................per lb........................

NOTE: Space for "Extras" such as anneal, machining, testing, special patterns, etc., are shown to be used if needed.

Form E

NON-FERROUS

Customer..Pattern Number....................

ESTIMATE OF SALES COST

Prepared by....................................Date...

	Our Alloy......lb.	@..........	$..........
Part Name..........................	Copper ....lb.	@..........	$..........
(Est.)...........................	Tin ....lb.	@..........	$..........
Weight (actual), ea...........	Lead ....lb.	@..........	$..........
No. pcs. required...............	Zinc ....lb.	@..........	$..........
Pieces per mold..................	Phosphorus ....lb.	@..........	$..........
Patt. ......Mach. .....Loose....	Nickel ....lb.	@..........	$..........
Green Sand......Dry Sand.....	Gross metal cost		
Flask size............................	Shrink ....lb.		
Cope...............Drag............	Net ....lb.		$..........
F.O.B.................................	Metal cost per lb.............%		

SUMMARY		ESTIMATE	ACTUAL
Cost of Metal.................		....	....
Conversion cost	........lb. @........	....	....
Direct molding labor......	.... @........	....	....
Molding burden	.......% of direct	....	....
Direct coremaking labor	@........	....	....
Core burden	........% of direct	....	....
Clean and ship.............	........% of direct mold and core	....	....
Machining labor and burden	.... @........	....	....
............Test labor and burden	.... @........	....	....
Special patterns, flasks, plates, etc.		....	....
Freight		....	....
Special deoxidizer and fluxes........		....	....
Chills		....	....
Chemical analysis or physical tests		....	....
Crating, cartons, etc., for shipping		....	....
Tools, dies, gauges, etc. (special)		....	....
Total Cost		....	....
Profit ....%		....	....
Total Sales....................		....	....

Selling price each.......................per lb........................

NOTE: Machining, testing, special patterns, etc., are shown to be used if needed.

FOUNDRY AND PATTERNMAKING PRACTICE IN A TRADE SCHOOL

H. W. Hershey
Instructor
Revere Trade School
Rochester, N. Y.

DIVERSITY OF TRAINING offered by foundry and patternmaking courses is not exceeded by any other school shop courses. The benefits derived by the student in such courses are threefold: first, he obtains a working knowledge of the production of castings which are so necessary in everyday life; second, he learns practical applications of related subject matter; third, he receives a sound foundation for a trade —a lifetime investment.

A great demand exists for young men in the foundry industry. The belief that the foundry is a place for those with strong backs and weak minds is proved erroneous by the caliber of individual sought by the foundry industry today. Foundry practice, in order to meet the exacting demands placed upon the casting industry, has become a science.

War Changed Foundries

Many requirements placed upon the foundries during the war have resulted in new methods, application of new materials, better working conditions, labor-saving devices and, most of all, an urgent need for young foundrymen. Technical, skilled and semi-skilled foundrymen are needed. The advancements made in the foundry industry warrant selection of the type of individual best suited for training and most likely to progress and succeed.

Communities in which foundries and patternshops operate should have some means of training apprentices or special help required by the industry. Many industrial training programs do not allow the time for detailed instruction that is received in a school training program; industry naturally places the emphasis on production.

In most cases, except in large plants, industry lacks personnel with the ability, training and time necessary to impart knowledge to others. Moreover, integration of related training with shop work is more advantageously carried on in a school training program.

School vs. Apprenticeship

A school course in patternmaking and foundry practice offers opportunities to a greater number of individuals than plant apprenticeship programs can hope to reach. In addition, trade school courses afford the best opportunity to attract individuals who otherwise might never have occasion to try their skill and knowledge in the foundry industry.

Above all, these courses offer young men an opportunity to develop skill, confidence and a sense of responsibility, and eliminate the chance that industry takes in hiring help from the street. The foundation offered by a trade school in either patternmaking or foundry practice is advantageous to the individual and to the industrial plant for which he works.

The general public has but little knowledge of the foundry industry. This is due in part to the fact that few people have an opportunity to visit a foundry. Visitors almost invariably express surprise at the skills and knowledge required in the foundry and patternshop to produce castings essential to the general welfare of the average citizen.

To obtain the caliber of student necessary to meet the foundry's needs for workers, the public must receive a true picture of the industry and the opportunities it offers. Foundry executives, foundry managers and chapters of the American Foundrymen's Association can assist in acquainting students, parents, and school administrators with the industry. Foundrymen should speak before school assemblies, set up and take part in apprenticeship courses, and aid, advise and promote the schools' training programs.

Acquainting the school board's guidance staff with the personnel needs of the industry will greatly aid the counselors in introducing prospective students to the foundry industry, and in guiding those most fitted for a foundry career.

Training Aids All

Training students for the skilled positions along with those for semi-skilled work aids all concerned. Working with the slower students, the brighter or more adept students illustrate an objective toward which the retarded students may strive, while the former gain experience in leadership and develop self-confidence.

By training a mixed group of elementary and advanced students the foundry cycle from molding to pouring off, and pattern construction from blueprint to completed pattern, is carried out more efficiently and safely. In addition, the student carry-over from term to term always leaves a nucleus upon which to build.

To be successful in either foundry

practice or patternmaking the student must possess the incentive and ability to work. He must progress and be stimulated from time to time through competition, praise, criticism, or some reward for his progress. The more advanced student's ability should be challenged constantly in order to make him more proficient. The longer a student remains in the course, the more proficient he should become; wherever necessary the instructor should create repetition to develop skill and emphasize fundamentals.

A class of 15 to 20 students in foundry and 12 to 15 in the patternshop is sufficient for each instructor to handle. Two 3-hour classes a day, one in the morning, the other in the afternoon, make up the maximum time a student can devote to practical training and also meet the requirements in related work necessary for graduation. Of the 3-hour period, the student spends about 2½ hours in class and the remainder changing his clothes and cleaning up for the next class. With other time-consuming activities taken out of shop time, the student averages about 12 hours per week for 38 weeks of the year.

The author favors running one foundry and pattern class for 5 full days, while the other class is taking its necessary related work for an equal number of days. By alternating in this manner, students can be given more instruction and the instructor can better organize his work.

Some time in the course organization should be allowed the instructor for lesson preparation, keeping records, grading papers, and checking equipment. No part of a foundry or pattern course, except for drafting and machinist apprentices, should be set up on a 10- or 20-week schedule. In this time students are barely introduced to foundry and pattern practice.

Patternmaking Student

A student specializing in patternmaking should begin in the foundry. There he should spend one-half to a full term, depending upon his progress, before he enters the pattern shop. This is based on class time of 12 to 15 hours per week. The patternmaking student, by spending some time in the foundry, gains a better understanding of pattern construction, moldability, foundry terminology, foundry physics, and care and use of all types of equipment.

Conversely, a foundry practice student should have at least a term in the pattern shop, either in his second or third year of foundry training. Experience in the pattern shop gives the foundry student an appreciation of patterns and their construction, some blueprint reading, and a better understanding of the possibilities of molding variously shaped patterns.

Select Trade

Students entering a vocational or technical high school should have had, or be introduced to, a general industrial arts program. Here a number of diversified activities set up on a small scale offer an opportunity for the student to explore various trades and professions. Proper observation and guidance enable the student to select the trade or profession he wishes to follow. This eliminates the time usually wasted by student and instructor in attempting to find out what the student wants to do.

In many cases, students fail to decide on a vocation even by the end of their senior year. This indicates a weakness in the school administration. The school board's guidance staff and industrial relations committee should make every effort to steer students in the right direction.

The foundry industry requires approximately 8,000 hours of training for its apprentices, or 2,000 hours per year. A student in school for 38 weeks can receive, at best, only 570 hours of appropriate foundry training. It can be readily seen that the student may waste no time if he expects to acquire any training at all.

A trade school student has an opportunity to put related subjects to practical use in the foundry and pattern shop. Foundry practice illustrates many practical applications of physics, chemistry, mathematics, and science in general. Even English, a subject disliked by many students, may be practiced in foundry work.

A course in Business English is most helpful. The use of trade terms, trade science, the history of the foundry industry and its association with our culture are but a few of the practical applications of related subject matter. Former students who went on to college have told the author that their foundry training helped them tremendously in college laboratory work.

One of the most important prerequisites to setting up any foundry and patternmaking course is to secure a well-qualified instructor. He should have a certified trade background and the ability to impart knowledge to others. The instructor's practical on-the-job foundry and pattern shop experience should be equivalent to the training other teachers receive in a 4-year college course. This experience should be reflected in a salary schedule.

No matter how well a shop is built and equipped, the course will not survive if the instructor is not qualified to teach. Students soon discover whether the instructor knows his business. If a student's ability is not challenged on every occasion, an instructor's life in the shop soon becomes unpleasant.

The best way to obtain well-qualified instructors is to make the position as attractive as possible. This may be done by paying the instructor more than he can earn in a plant or at a bench, by establishing and equipping a school shop as nearly like commercial shops as possible, and by not basing salary increases on college credits or degree standards. The instructor should have backing in his associations with the foundry trade, and should be allowed to judge and appraise possible trade or technical students in relation to his own standards.

If a school foundry and pattern

Evening school students pouring off a column for a drill press. Mold poured two up.

General Outline of Basic and Advanced Course in Foundry Integrated With Pattern Course

I. Introduction
- A. History of Foundry Industry
- B. Place and Importance in Metal Working Field
- C. Types of Foundries
- D. Processing of Casting Metals from Mine to Foundry
- E. Foundry Products
  1. Ferrous
  2. Non-ferrous
- F. Divisions of Foundry
  1. Supervision
  2. Metallurgist
  3. Pattern Clerk
  4. Time Checker
  5. Rigger
  6. Patternmakers
  7. Molders
  8. Coremakers
  9. Crane Operator
  10. Molders' Helpers
  11. Laborers
  12. Melters
  13. Furnace Operators
  14. Shake-out Gang
  15. Casting Cleaners
  16. Casting Inspectors

II. Foundry Terminology

III. Foundry Tools and Equipment
- A. Hand
- B. Machine

IV. Foundry Flasks and Rigging
- A. Care
- B. Use
- C. Sizes and Shapes
- D. Bottom Boards and Molding Boards
- E. Clamps and Weights
- F. Arbors

V. Patterns
- A. Types
- B. Color Markings
- C. Construction
- D. Care

VI. Foundry Sands
- A. Molding
- B. Core

VII. Sand Handling and Processing
- A. Machine
- B. Hand

VIII. Sand Testing
- A. Grade
- B. Moisture Content
- C. Permeability
- D. Green Strength
- E. Dry Strength
- F. Refractoriness
- G. Microscope Study
- H. Clay Content
- I. Fineness

IX. Fundamental Principles of Molding

X. Sequential Steps in Molding Course
- A. Flat Back
- B. Flat Back with Green Sand Core
- C. Coping Partings
- D. Flat Back with Dry Sand Core
- E. Split Patterns
- F. 3-part Pattern (3-part Flask)
- G. Bedding-in
- H. Printing Back
- I. Follow Board (Sand Match)
- J. Pattern with Cover Core
- K. Pattern with Tail Prints
- L. Pattern with Loose Pieces
- M. Gated Pattern
- N. Boarded Pattern
- O. Molding with Sweeps
- P. Casting in Core
- Q. Pattern with Number of Cores Requiring Use of Chaplets

XI. Machine Molding
- A. Squeezers
- B. Jolt-squeezers
- C. Jolt, Roll-over, and Stripper (Description)
- D. Sand Slingers (Description)

XII. Molding-in
- A. Green Sand
- B. Dry Sand

XIII. Melting Equipment both Ferrous and Non-Ferrous (Description)
- A. Melting Units
  1. Brass, Bronze and Aluminum
  2. Malleable Iron
  3. Steel
- B. Linings for Melting Equipment

XIV. Foundry Fuels
- A. Coke
- B. Oil
- C. Gas
- D. Electricity
- E. Powdered Coal

XV. Cupola Theory and Operation
- A. Determining Charge
- B. Determining Bed Height
- C. Number of Charges
- D. Proportion of Materials
- E. Chemical Reactions
- F. Volume of Air
- G. Air Resistance
- H. Temperature
- I. Melting Rate

XVI. Refractories and Fluxes

XVII. Non-Ferrous Furnace Operation

XVIII. Metal Handling
- A. Ladle Lining and Care of Crucibles
- B. Mold Pouring

XIX. Coremaking
- A. Sand Preparation
- B. Sand Handling
- C. Types of Cores
- D. Core Reinforcing
- E. Core Venting
- F. Core Coatings and Pasting
- G. Core Drying
- H. Core Storage

The course outlined is to be supplemented by guest speakers, moving pictures and plant visitations.

General Outline of Basic and Advanced Course in Foundry Integrated With Pattern Course (Cont.)

XX. Casting Cleaning
- A. Tumbling
- B. Sandblasting
- C. Chipping
- D. Grinding

XXI. Casting Inspection
- A. Shrinks
- B. Cracks
- C. Surface Texture
- D. Blow Holes
- E. Rattails
- F. Sand Holes
- G. Cold Shuts
- H. Cored Holes
- I. Mismatches

XXII. Safety and Good Shop Keeping
- A. Sanitation
- B. First Aid
- C. Care of Tools, Equipment, and Materials
- D. Safety Devices
- E. Personal Attitude and Dress

NOTE: To avoid losing time so necessary for the completion of shop practice, the rest of this course outline should be taught apart from the general courses in either patternmaking or foundry practice. However, it should be a correlated part of the courses integrating the subject matter wherever possible. This section will serve the needs of students in other related trades taught by related instructors, specialists in their field.

XXIII. Foundry Technology
- A. Materials
- B. Terms
- C. Processes of Trade

XXIV. Fundamentals of Mathematics

XXV. Foundry Mathematics and Problems
- A. Ratio and Proportion
- B. Weights and Measurements
- C. Graphs
- D. Shop Geometry
- E. Shop Trigonometry
- F. Liquid Measure
- G. Dry Measure
- H. Use of measuring instruments common to the trade

XXVI. Elementary Blue Print Reading
- A. The Basis for the Interpretation of Blue Prints
- B. Three View Drawings
  1. Three-view Projection
  2. Visible Outlines
  3. Dimensions
  4. Visible Edges
  5. Location of Dimensions
  6. Fractional Dimensions
  7. Invisible Edges
  8. Measurement of Angles
  9. Scale Drawings
  10. Fillets and Rounds
- C. Two View Drawings
  1. Projection of Cylindrical Work
  2. Dimensioning of Cylindrical Work
  3. Invisible Circles
  4. Fractional Tolerances
  5. Decimal Dimensions
  6. Drilled Holes
  7. Angular Dimensions
  8. Angular Tolerances
  9. Tapers
- D. One View Drawings
- E. Sectional Drawings

XXVII. Pattern and Foundry Blue Print Reading
- A. Pattern Dimensions
  1. Finish Marks
  2. Finish Allowance
- B. Checking Patterns
  1. Specifications of Drawings
  2. Moldability
- C. Checking Castings with Blue Print

XXVIII. Shop Sketching
- A. Positioning Views from Objects
- B. Sketching Objects from Blue Prints
- C. Sketching Methods of Construction

XXIX. Trade Science and Theory
- A. Sand Control
- B. Sand Testing
- C. Chemistry of Materials
  1. Changes of Matter
  2. Structure of Matter
  3. Combination of Elements
  4. Chemical Attraction
  5. Cohesion and Adhesion
  6. Contraction, Shrinkage, and Expansion
  7. Acids, Bases, and Salts
- D. Metallurgy
  1. Iron
  2. Steel
  3. Non-Ferrous Metals
  4. Microscopic Study of Grain Structure
  5. Strength of Materials
  6. Structural Design
  7. Physical Tests
- E. Applied Foundry Physics
  1. Force
  2. Work
  3. Energy
  4. Power
  5. Motion
  6. Gravity
  7. Heat
  8. Light
  9. Electricity and Magnetism
  10. Simple Levers
  11. Tackle Blocks and Pulleys
  12. Gears
  13. Inclined Planes
  14. Wedge and Screw
  15. Transmission of Pressure by Fluids
  16. The Hydraulic Press
  17. Pneumatic Tools and Equipment
  18. Steam
- F. Principles of Foundry Production Methods
  1. Continuous Pouring
  2. Production Methods

XXX. Industrial and Labor Relations

XXXI. Business English

XXXII. Foundry Costs

XXXIII. Casting Estimating

XXXIV. Foundry Organization and Operation

XXXV. How to Hold and Advance on the Job

shop course is to be successful and the students are to receive training of any value, then the prime objective should be to teach the subject according to a course outline. Nothing that will waste the time of the instructor and the students should be included.

The greatest compensation for any instructor's efforts is the success of the finished student. Well-trained students should be the aim of every instructor. False advertising, a showy classroom, polished equipment that is rarely used and reams of instructional material may be impressive to visitors, but have little place in a properly organized course of study. The author does not mean to imply that equipment should not receive care, or that there should be no organized course of study. Both should be properly used.

Interest the Student

A course of study in which a practical project is started and finished, and in which the various trades are correlated, interests the student and affords him the most experience. For example, one or more of the following projects may be started in the drafting department: vise, surface plate, lathe, drill press, punch press, variety saw, band saw, etc.

After a short course in elementary drafting, students under the guidance of a capable instructor can, and have, designed parts for the various projects. When the drawings are completed, they are sent to the machine shop, pattern shop, welding shop, or wherever the part is to be made. This automatically carries on interest and the learning cycle, instead of stopping it with the drawings, patterns or castings.

The other shops carry out their part of the sequence. The pattern shop students make the patterns, students in the foundry make the castings, and the machine shop students machine them. The students are allowed to buy the finished articles at cost.

A program of this type is as practical as the various instructors wish or are able to make it. When a student finishes a practical integrated program of this type, his period of apprenticeship should be decreased, thus making him an asset to the foundry industry in a shorter period of time.

Some instructors object to this type of program because it requires considerable individual instruction. Such an objection usually comes from the instructor who wishes to do his teaching in comfort from behind a desk.

Locating Foundry

Design and location of the foundry and pattern shop building should be taken up with a committee of local foundrymen who understand foundry and pattern shop layout and operation. Chapters of the American Foundrymen's Association are always willing to assist vocational schools, and many chapters have educational committees for this purpose. The instructor should also be allowed to participate in the planning of the school foundry and pattern shop.

The cost of setting up and operating a practical foundry and patternmaking training program in a school depends upon the space allotted and the scope of the course. Foundry equipment may cost from $18,000 to $30,000; for a pattern shop the equipment may cost from $8,000 to $15,000. These figures are based on machinery and equipment that will withstand the severe usage and wear that most beginning students are likely to give it.

The amount invested in a well organized trade school course is returned in a short time in the form of savings in castings and patterns in addition to the wealth of training obtained for the tax dollar.

While the author was an instructor in foundry and pattern practice in Syracuse, N. Y., all of the castings and some of the patterns for the school board maintenance of heating and operation equipment were made as part of the school shop course. The average amount of iron melted per week was approximately 1½ tons.

Many former students of the course now are employed in the industries of Syracuse; others entered the technical fields after graduating from college. Industry was much interested in the school training program. Some foundries and pattern shops allowed graduates of the school training program credit toward apprentice programs.

The course in foundry and patternmaking at the Revere Trade School, Rochester, N. Y., where the author is now employed as instructor, is operated as nearly like a commercial foundry as floor space and equipment will allow. Both foundry and pattern shop offer basic training for the beginner, correlated advanced training for the more advanced pupils, and special training for those wishing to specialize in any definite phase of foundry or pattern practice. Either the foundry or the patternmaking course will serve the needs of a student planning to enter engineering college, or of a student choosing either as a trade.

Student at work on molding machine.

Divisions of the foundry trade taught are bench, floor, and machine molding for both ferrous and nonferrous practice, coremaking, and casting finishing, setting up, operation and care of melting equipment, rigging, casting inspection and sand testing.

Space and Equipment

Foundry and pattern shop have 3,000 sq. ft. of floor space, including 1,200 sq. ft. for storage. The foundry will accommodate 20 students and the pattern shop has space for 10 students. The foundry is equipped with all the necessary hand tools and other equipment. This includes a small standard cupola with a skip hoist, a crucible furnace, an automatic, heat-circulating type core oven, a muller, and two mechanical sand conditioners and blenders.

Molding equipment includes eight bench molding spaces, and two types of jolt-squeeze machines. Flasks for floor molding range in size from 14x24 in. to 60x60 in. In the cleaning room there is a large tumbling barrel, a sandblast cabinet, a large 18-in. double wheel grinder, two portable air grinders, and two pneu-

General Outline of Basic and Advanced Course in Patternmaking Correlated With the Foundry Course

I. Introduction to Patternmaking
- A. History and Development of Patternmaking
- B. Importance of Patternmaking in Structural and Mechanical Fields
- C. Types of Patterns
- D. Patternmaking, Its Relation to the Foundry
- E. Divisions of Patternmaking
- F. Occupational Opportunities in the Pattern Shop
- G. Pattern Shop Safety and Hygiene

II. Fundamental Principles
- A. Materials
- B. Pattern Lumber
- C. Common Pattern Joints
- D. Metal

III. Principal Layout Tools
- A. Knife
- B. Square
- C. Gage
- D. Shrink Rules
- E. Dividers
- F. Bevel
- G. Protractor
- H. Scriber
- I. Surface Gage

IV. Pattern Layouts
- A. Shrinkage
- B. Direction of Grain in Respective Pieces (Wood)
- C. Mechanical Drawing Symbols
- D. Allowances for Finish and Draft
- E. Allowances for Core Prints
- F. Laying Out Center Lines

V. Use of Patternmaker's Vise

VI. Pattern Construction
- A. Joinery
- B. Fitting
- C. Securing

VII. Operation and Care of Pattern Shop Machines
- A. Swing Saw
- B. Circular Saw
- C. Jointer
- D. Planer
- E. Band Saw
- F. Sander (Spindle and Disc)
- G. Lathe
- H. Drill Press
- I. Jig Saw
- J. Portable Router
- K. Tool Grinder

NOTE: Safety precautions to be observed during the operation of these machines should be discussed at the time of the lesson on each machine.

VIII. Tool Grinding
- A. Knives
- B. Chisels
- C. Gouges
- D. Carving Tools
- E. Bits
- F. Dividers
- G. Lathe Turning Tools
- H. Saw Filing (Machine and Hand)

IX. Use of Other Hand Patternmaking Tools
- A. Hammers
- B. Steel Square
- C. Panel Gage
- D. Surface Plate
- E. Surface Gage.
- F. Triangles
- G. Trammel Set
- H. Inside and Outside Calipers
- I. Planes (Care and Adjustment)
- J. Brace
- K. Hand Drill
- L. Screwdrivers
- M. Drills
- N. Hand Saws

X. Patternmaking Technology
- A. Materials
- B. Terms
- C. Processes of Trade
- D. Some Common Formulas for Mixtures

NOTE: To avoid losing time so necessary for the completion of shop practice, the rest of this course outline should be taught apart from the general courses in either patternmaking or foundry practice. However, it should be a correlated part of the courses integrating the subject matter wherever possible. This section will serve the needs of students in other related trades taught by related instructors, specialists in their field.

XI. Fundamentals of Mathematics

XII. Pattern Shop Mathematics
- A. Addition, Subtraction, Division, Multiplication
  1. Decimals
  2. Fractions
- B. Liquid Measure
- C. Dry Measure
- D. Shop Geometry—Construction
- E. Shop Trigonometry—Construction
- F. Use and Interpretation of Some Measuring Instruments Common to the Trade
- G. Graphs

XIII. Elementary Blue Print Reading
- A. The Basis for the Interpretation of Blue Prints
- B. Three View Drawings
- C. Two View Drawings
- D. One View Drawings
- E. Sectional Drawings

XIV. Pattern and Foundry Blue Print Reading
- A. Pattern Dimensions
  1. Finish Marks
  2. Finish Allowance
- B. Checking Patterns
  1. Specifications of Drawings
  2. Moldability
- C. Checking Castings with Blue Prints

XV. Shop Sketching
- A. Positioning Views from Objects
- B. Sketching Objects from Blue Prints
- C. Sketching Methods of Construction

XVI. Trade Science and Theory
- A. Knowledge of Materials
- B. Expansion and Contraction
- C. Metal Shrinkage
- D. Tool Grinding and Maintenance
- E. Feeds and Speeds
- F. Strength of Materials
- G. Structural Design
- H. Chemistry of Materials
- I. Applied Patternmaking Physics
- J. Applied Pattern and Foundry Practice

XVII. Industrial and Labor Relations

XVIII. Pattern Shop Cost

XIX. Pattern and Casting Estimates

XX. Pattern Shop Organization and Operation

XXI. How to Hold and Advance on the Job

matic chipping hammers. The latest addition to the foundry is the sand testing laboratory. This is equipped with up-to-date sand-testing equipment.

The pattern shop is equipped with a variety saw, 18-in. jointer, 24-in. planer, 36-in. bandsaw, drill press, oilstone grinder, wood-turning lathe, disc and spindle sander, flexible shaft grinder, and portable router. All the necessary hand patternmaking tools are available in suitable cabinets.

Requirements of Pupils

For the foundry course the pupil must be at least a first year high school student, physically fit, willing to work and follow orders. The foundry student must possess or be able to develop a high degree of responsibility and self-confidence.

A pupil specializing in foundry practice should have at least one year of mechanical drawing and be able to read blueprints. A fourth-year student is given a term of correlated patternmaking and a course in materials of industry. Training in foundry metallurgy is given in the third or fourth year, depending upon the science background of the student.

A student entering the pattern trade should be at least a first year high school student with at least a year of mechanical drawing. He should be able to work with fractions and decimals and have some knowledge of geometry. While studying patternmaking he should take a course in materials of industry, also, elementary and advanced machine design. If the student specializes in patternmaking, he is given from a term to a year of foundry practice in his 3- or 4-year course, depending upon the number of hours he has completed in the course.

Operations in the foundry and pattern shop are as nearly like industrial procedure as possible in order to give the student an all-around practical training. There is but little practice work; nearly everything made has utility value. Castings for all the machine shops in the Rochester school system are supplied by the foundry of the Revere Trade School. Maintenance and repair castings and patterns for the various schools in the system are also made at this trade school.

Some of the patterns and castings being made at present are those for vises, angle plates, replacements for broken machine parts, drill presses, surface plates, checking fixtures, novelties, and stock pieces of various shapes for the machine shops. At present, one 2-ton heat of iron is poured every 2 or 3 weeks.

Students are allowed to progress as rapidly as their ability permits. Some students are employed in foundries on a part-time basis.

The school foundry participated actively in the war effort by producing castings and by offering training courses. All of the original "kirksite" dies for a blister ball turret on a fighter bomber were cast from plaster patterns for a local manufacturing concern. Approximately six tons of metal were cast to make these dies. Forty sets of ordnance inspection training forms, each set weighing 1,800 lb., were cast and shipped to the various training centers.

Night molding and patternmaking classes were formed in which full and part-time workers were trained for war work. At times, two 3-ton heats of iron were poured in a week.

Pouring molten iron from mixing ladle in school foundry.

BOARD REVISES PROGRAMS

(Continued from Page 48)

the immediate past Division Chairman, the chairmen of principal committees and not more than three additional members at large. At its discretion, the Executive Committee may authorize appointment of an Advisory Group, composed of not more than 12 individuals held in high esteem but too occupied to serve on committees. Such individuals may be called upon to serve in advisory capacity, but will not be expected to participate actively.

Also considered in the National Office memorandum are qualifications of Division Officers, methods of their selection and terms of office; standing committees; reports; subcommittee organization; selection of committee officers and their duties; committee appointments; representation in other societies and associations; and a brief outline of the plan for A.F.A.-sponsored research projects.

Fundamental principle of the latter is that future research activities of the Association shall originate with the membership, as expressed through divisional committees, and shall be conducted in a manner consistent with basic A.F.A. objectives. Research Committees will be appointed for the Gray Iron, Steel, Malleable, Brass and Bronze, Aluminum and Magnesium and Foundry Sands groups.

Research Committees are to conceive, recommend, plan, supervise and report on worthwhile projects for investigation. They are empowered to recommend one project in any fiscal year to the A.F.A. Executive Committee, which shall authorize expenditures for such projects as it approves.

Maximum annual expenditure for any research undertaking of a Division is limited to five thousand dollars; however, two or more Divisions may pool their interests behind a single project. Following approval of the A.F.A. Executive Committee, the A.F.A. Technical Director will act as chief of liaison between that body, the Research committees and selected contractors.

The procedure established is designed to utilize the foremost talent in the industry to direct research, so that reliable technical information may be obtained for the improvement of foundry products and accomplishment of economies in operation through technical advancement.

A.F.A. Publishes 1946 Registration List

REGISTERED ATTENDANCE LIST of the Golden Jubilee Convention, held in Cleveland May 6-10, has been printed and distributed to all firms which exhibited at the 1946 Show.

Well over ten thousand names of top management and operating personnel are shown, together with those of others who directly affect the purchase of equipment and supplies for foundries. Issued primarily in the interest of exhibitors, the list is arranged geographically, for the first time, to facilitate ready reference by chapter officers and sales organizations.

Non-exhibitors who require such up-to-date information may obtain copies at $10.00 each. Requests for the 1946 REGISTERED ATTENDANCE LIST should be directed to the American Foundrymen's Association, Department of Exhibits, 222 W. Adams St., Chicago 6, Ill.

Health Officer Praises Castings Industry Role

FOUNDRY BACKGROUND of Claude R. Strickland, who won the Legion of Merit while a Technical Sergeant with the 29th Malaria Control Detachment in West Africa for outstanding service involving construction of an improvised foundry*, consisted of completing a course with the McClain System, Inc., Milwaukee, and striving unsuccessfully to serve an apprenticeship during the difficult early '20s.

However, the familiarity with foundry technology he acquired in the brief association proved invaluable to Mr. Strickland when his career in public health service resulted in assignment to similar work with the armed forces, and brought him into a situation where construction of a power duster with metal components was imperative.

Describing the "exceptionally meritorious conduct in the performance of outstanding service" of the then Sergeant Strickland, the Citation by Major General B. F. Giles concludes, ". . . in his spare time cast parts by melting aluminum alloy found in a plane dump and duplicated his original machine in metal.

"The ingenuity, resourcefulness and technical ability displayed by Sergeant Strickland contributed greatly to the successful completion of the malaria control program of the area."

Now returned to his civilian occupation as Senior Sanitarian, Pinellas County Health Department, St. Petersburg, Fla., Mr. Strickland writes AMERICAN FOUNDRYMAN that "where civilization has reached its highest order the works of the foundryman are abundantly evident.

"His contributions to public health are manifold, and monuments to his genius constitute the heart of every waterworks and sewage disposal plant. No less can be said of his contributions in every field of human endeavor. Truly, civilization marches behind, not in front of him."

*See page 83, AMERICAN FOUNDRYMAN, June, 1946.

Former Technical Sergeant Claude R. Strickland, 29th Malaria Control Detachment, looks over a few of the castings produced by his "home made" foundry.

British Foundrymen Hold Annual Meeting

CONVENING for its 43rd Annual General Meeting recently at the Grand Hotel, Birmingham, the Institute of British Foundrymen reported a gratifying increase in membership; a number of honors and distinctions conferred upon members during the year, including the award of M.B.E. to Tom Makemson, Secretary; and the issuance of outstanding foundry publications during the past year.

Total membership of the Institute increased 16 per cent between April 30, 1945, and April 30, 1946; from 3,366 to 3,569, respectively.

Mr. Makemson, on loan to the Ministry of Supply, as Director for Iron Castings, Iron and Steel Control, was honored for his accomplishments in that office.

Specifically cited as outstanding among published technical material were the first report of the Joint Committee on Sand Testing, "Methods of Testing Prepared Foundry Sands,"* and "Lectures in Foundry Practice," prepared by the Education Committee, edited by the Secretary and published for limited circulation to technical colleges and teachers.

Choosing officers for the coming year by unanimous vote, the Institute named D. Howard Wood, Constructional Engineering Co. Ltd., Birmingham, as President. P. H. Wilson, O.B.E., was elected Senior Vice-President; and R. B. Templeton, Ealing Park Foundry, Ltd., London, was named Junior Vice-President.

Report of the Council of the Institute noted partial resumptions of normal relations with other societies, and reported on the attendance of a delegation at the A.F.A. Golden Jubilee Convention in Cleveland.

*See page 79, AMERICAN FOUNDRYMAN, June, 1946.

Moves Headquarters

The Gray Iron Founders' Society, Inc., has closed its Washington, D. C., office, and now maintains headquarters at 1010 Public Square Building, Cleveland.

ALUMINUM CASTING ALLOY 3 PER CENT CU : 5 PER CENT SI

Methods for recovery of airplane aluminum scrap have been developed, and have made available an excellent source of material for the production of general purpose aluminum alloys.

O. Tichy
Metallurgist
The National Smelting Co.
Cleveland

IN RECENT MONTHS the literature has contained treatises on the utilization of the enormous amounts of airplane scrap. Technical magazines of late have brought such headlines as "From War Planes to Kitchenware," the articles describing a suggested method of converting the available aluminum into alumina and then by electrolysis back into pure aluminum.

Dr. N. H. Engle[1] referred to this process as one which probably would be as expensive as the production of aluminum from bauxite. One of the possible advantages is that of conservation. However, this would not appeal to those who desire a less expensive source of the metal. In the same article are a few comments about a relatively simple process which consists of careful melting of sorted scrap in a special type of furnace, the end product of which is said to be suitable for cast and wrought purposes.

This latter reference is one of the few to a modern method of reclaiming the useful aluminum alloys from obsolete, battle-damaged and war-weary planes, although it has already been applied on a production scale and useful alloys have been recovered from such scrap materials.

Another reference is given by E. J. Hardy[2] who describes this process as the Navy recently has put it into practice. Some precautions as to procedure are mentioned, which are expected to result in good, useable alloys at a reasonable price.

Airplane scrap was put to good use by the smelting industry during the war when the resultant alloys had to conform to the most stringent specifications. Following is a partial list of alloys, familiar to foundrymen, which were produced and utilized during the war for the production of various types of castings: 4 per cent copper, 2 per cent silicon; 4 per cent copper, 3 per cent silicon; 4 per cent copper, 5 per cent silicon; 4 per cent copper, 9 per cent silicon; and aluminum-copper-magnesium-manganese-silicon alloys containing 5, 8, and 10 per cent of silicon.

Reclaiming Scrap

As has been mentioned previously, the reclamation of airplane scrap has been done on a commercial scale with good results. A sloping hearth is used for this process. Sorting to remove any lead present keeps this element at a sufficiently low concentration so that it does no harm. The aluminum is "sweated" from any iron or other high-melting alloys present, and the latter raked out before they can alloy with the aluminum.

Analyses of several heats of metal produced with this procedure are reproduced in Table 1. These data represent a cross-section of metal recovered from many types of airplane scrap, and it can be seen at a glance that useful alloys can and are produced with such material.

During the war the aluminum industry had to cast alloys of the conventional types due to rigid standardization. The price of an alloy was not too significant a factor then, but peace-time competition places a different aspect on this problem.

For a considerable period the No. 12 alloy, which is basically an 8 per cent copper alloy, was used to produce a large variety of castings of both the sand and permanent mold types. During the war period, due to the large amount of wrought material scrap made available, a large quantity of alloys containing copper and silicon were cast. This type of alloy has better castability and exhibits better mechanical properties than the No. 12 alloy. It can now be readily produced from the

Table 1

ANALYSES OF METAL PRODUCED FROM AIRPLANE SCRAP

Lot No.	*Cu*	*Fe*	*Pb*	*Mg*	*Mn*	*Ni*	*Si*	*Sn*	*Zn*	*Cr*	*Al*
B 943	0.35	0.29	0.01	0.94	0.09	0.14	0.70	0.01	0.05	0.23	97.30
B 944	0.32	0.33	0.01	0.94	0.09	0.09	0.61	0.01	0.05	0.26	97.31
B 946	0.12	0.90	0.01	2.22	0.05	0.01	0.19	0.01	0.12	0.23	96.17
B 951	3.86	0.61	0.09	1.40	0.52	0.01	0.47	0.02	0.22	0.03	92.83
B 957	1.56	0.49	0.06	1.41	0.09	0.03	4.53	0.05	0.23	0.08	91.56
B 959	3.58	0.70	0.44	1.03	0.50	0.03	0.56	0.01	0.14	0.07	92.98
B 962	4.20	0.53	0.10	1.45	0.58	0.01	0.23	0.01	0.02	0.03	92.86
B 963	4.15	0.51	0.16	1.24	0.58	0.01	0.14	0.01	0.02	0.02	93.17
B 965	3.98	0.45	0.06	0.74	0.69	0.02	0.51	0.01	0.06	0.03	93.48
B 970	1.61	0.48	0.03	1.36	0.03	0.01	4.10	0.04	0.05	0.10	92.18

Presented at an Aluminum and Magnesium Session of the Fiftieth Annual Meeting, American Foundrymen's Association, at Cleveland, May 7, 1946.

types of materials recorded in Table 1.

It has been recognized for some time that duralumin is not a good casting alloy. In order to utilize this raw material, two general methods were available to improve its castability. One method was to raise the copper content to 7 or 8 per cent, as in the old conventional No. 12 alloy, and the other was to add silicon which, as is well known, increases the fluidity of most aluminum alloys[4]. Since copper also was scarce during the war and silicon afforded the easier casting alloys, it was logical for the silicon additions to be the first choice.

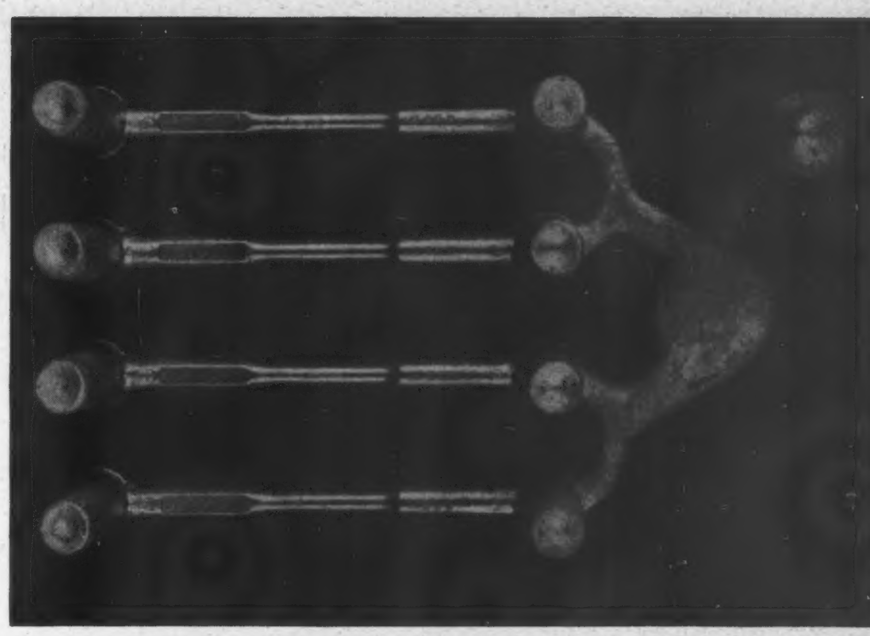
Emergency specifications, such as the AXS series, were developed by the armed services with the aid of specification-writing societies. The limits in silicon content were exceptionally wide and permitted several alloy series within the specifications. Many specific alloys were developed within these series by various users to suit their methods of casting.

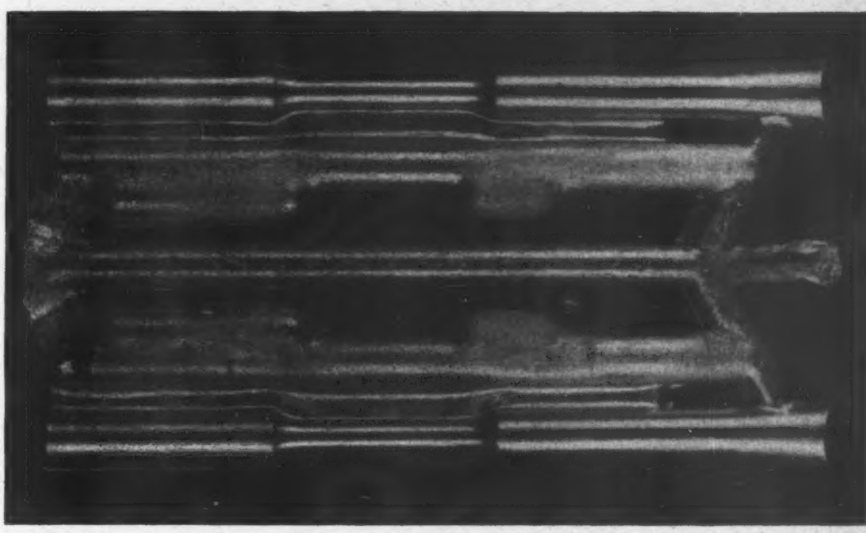
Study Best Composition

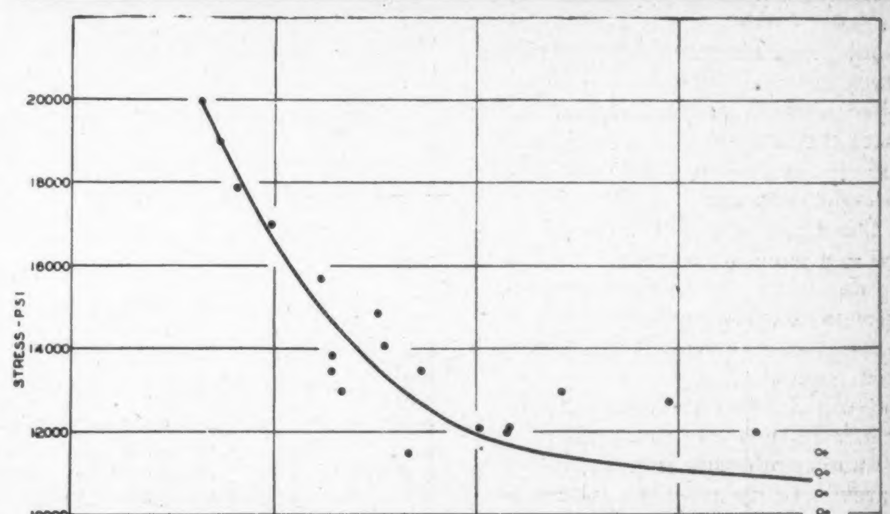
In the production of these various alloys, a field was found which indicated the possibility of interesting properties. Studies were made in various directions to find the best composition which would give an alloy easily produced from existing raw materials.

It was also desirable to have an alloy possessing good casting and mechanical properties without resort to solution heat treatment and still be able to materially enhance these properties by heat treatments if necessary. As a result of this work, an alloy was developed having basically a typical composition of 3 per cent copper and 5 per cent silicon.

Good mechanical properties are developed in this alloy in both the as-cast and heat-treated conditions, and it may be cast in either sand or permanent molds. As will be seen







Reading from top to bottom:
Fig. 1—Four-bar aluminum test specimen cast in green sand at temperatures of 1260-1280° F.
Fig. 2—Type of permanent mold aluminum test casting.
Fig. 3—Endurance limit of sand-cast aluminum alloy—solution heat treated and aged.

Table 2

PROPERTIES OF SAND CAST ALUMINUM ALLOYS

Heat No.	Yield Strength, 0.2% Offset, psi.	Tensile Strength, psi.	Elongation, % in 2 in.	Brinell Hardness. 500-kg. load
AS CAST[1]				
X-273 B	14000	26600	3.3	62
X-274 B	14100	26500	3.5	61
SOLUTION HEAT TREATED AND AGED[2]				
X-273 B	18200	33800	4.5	72
X-274 B	18400	33200	4.2	69
355-T 6	25000	35000	3.5	80
356-T 6	22000	32000	4.0	70
STRESS RELIEVED[3]				
X-273 B	16100	29100	2.8	64
X-274 B	16400	28900	3.0	64
355-T 51	23000	28000	1.5	60
356-T 51	20000	25000	2.0	60

[1] One day at room temperature.
[2] 960° F.—12 hr., hot water quench, 300° F.—3 hr.
[3] 440° F.—8 hr.

Table 3

PROPERTIES OF CHILL CAST ALUMINUM ALLOYS

Heat No.	Yield Strength, 0.2% Offset, psi.	Tensile Strength, psi.	Elongation, % in 2 in.	Brinell Hardness, 500-kg. load
AS CAST[1]				
X-57 B	15500	30100	3.2	70
X-58 B	14800	30600	3.5	69
SOLUTION HEAT TREATED AND AGED[2]				
X-57 B	18500	38400	6.2	78
X-58 B	17900	39400	7.0	75
355-T 6	26000	43000	4.0	90
356-T 6	24000	40000	5.0	90
STRESS RELIEVED[3]				
X-57 B	19000	33500	2.3	73
X-58 B	18300	34500	2.8	73
355-T 51	24000	30000	2.0	75

[1] One day at room temperature.
[2] 960° F.—6 hr., hot water quench, 300° F.—3 hr.
[3] 440° F.—8 hr.

later, the properties developed are substantially the same as those of AN-QQ-A 376, SAE 322, and ASTM SC 21, which contain basically 1.3 per cent copper, 0.5 per cent magnesium and 5 per cent silicon and shall be referred to later as alloy 1; and AN-QQ-A 394, SAE 323, and ASTM SG 1, which contain basically 0.3 per cent magnesium and 7 per cent silicon and shall be referred to as alloy 2.

In order to obtain properties under conditions similar to commercial practice, the test specimens were cast at a temperature range of 1260 to 1280° F. into green sand molds. The type of casting made is shown in Fig. 1. Average properties obtained with this procedure, consisting of from four to eight individual tests, are listed in Table 2 along with typical values of alloys 1 and 2 taken from the literature[3].

In the as-cast condition this copper-silicon alloy gives tensile strength as high or higher than No. 12 alloy but has much greater elongation. Typical elongation for sand-cast No. 12 alloy is about 1 to 1.5 per cent. In the solution heat treated and aged state (Table 2) this alloy surpasses No. 12 alloy, which can not be markedly improved by such treatment, and it becomes equal or better than No. 2 alloy in strength and elongation, and better in elongation than No. 1 alloy. The only marked difference is found in the low yield strength; No. 2 alloy exhibits higher yield strength and No. 1 alloy still higher.

In the stress-relieved condition the alloy gives a tensile strength equal

Table 4

PHYSICAL PROPERTIES

Heat Treatment	Appr. Thermal Conductivity[1]	Appr. Electrical Conductivity[2]
As Cast	0.25	27
Solution Heat Treated and Aged	0.27	29
Stress Relieved	0.28	31

Thermal Expansion, in./in./° F. (68-212° F.)	12.2×10^{-6}
Specific Gravity	2.76
Weight, lb./cu. in.	0.100

[1] Thermal conductivity values calculated from electrical conductivity. C.G.S. units are calories per square centimeter per degree centigrade per second.
[2] Electrical conductivity, per cent International Annealed Cu. Standard at 68° F.

Table 5

PROPERTIES OF CHILL CAST (0.05-0.11% MG.) ALUMINUM ALLOYS

Heat No.	Yield Strength, 0.2% Offset, psi.	Tensile Strength, psi.	Elongation, % in 2 in.	Brinell Hardness, 500-kg. load
AS CAST				
5112	20600	35000	2.7	84
5116	19400	34600	3.2	80
5122	19700	35000	3.3	79
5125	20300	35200	3.4	78
SOLUTION HEAT TREATED AND AGED				
5112	24100	40800	4.2	91
5116	23700	41500	4.6	91
5122	22300	42400	5.9	88
5125	22400	41600	5.3	89
STRESS RELIEVED				
5112	22900	36900	2.7	81
5116	25200	38200	3.2	83

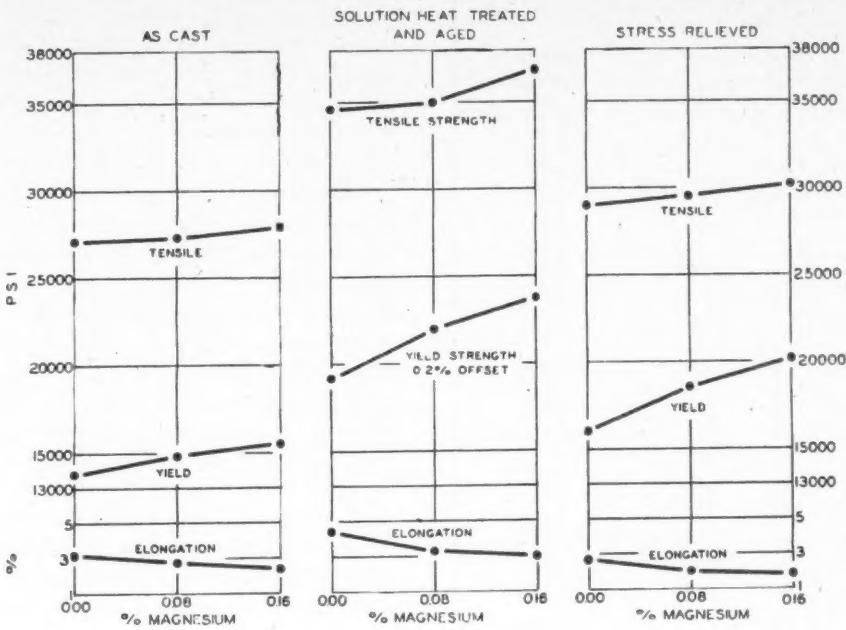


Fig. 4—Effect of magnesium on properties of sand-cast aluminum test specimens.

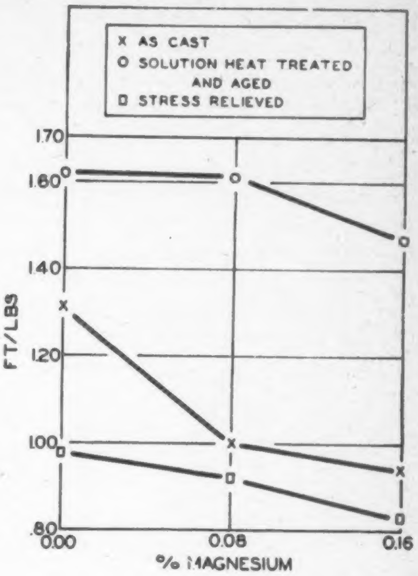


Fig. 6—Effect of magnesium on sand-cast aluminum impact test speciments.

to or greater than that of the No. 1 alloy and greater than that of the No. 2 alloy, while the ductility is greater than in either. Here again the yield strength is somewhat lower. This is easily explained by the larger amount of magnesium present in the latter two alloys. However, the yield strength in this new alloy can be altered, as will be shown later.

Other heats were made using the same melting and casting technique, and permanent mold castings of the type shown in Fig. 2 were made. Average properties of these chill-cast specimens, constituting four to six bars in each case, are shown in Table 3. The as-cast condition developes a good tensile strength with a fair amount of ductility.

Solution heat treated and aged, this alloy has a lower tensile strength and yield strength than No. 1 and No. 2 alloys, but has somewhat higher ductility. In the stress-relieved condition the tensile strength and ductility exceed that of No. 1 alloy, with the yield strength again being somewhat lower.

Fatigue strength values of alloys are considered essential by designing engineers today. Specimens were cast into green sand molds of a design similar to those used for the tensile specimens and tested with R. R. Moore type fatigue machines.

At present, the only test com-

Table 6

ALLOY COMPOSITION

Element	*Per Cent*
Copper	2.5-3.5
Silicon	4.5-6.0
Magnesium	0.15 max.
Iron	1.0 max.
Nickel	0.2 max.
Manganese	0.5 max.
Zinc	0.7 max.
Elements employed to obtain special properties	0.5 max.
Other elements	0.3 max.
Aluminum	Remainder

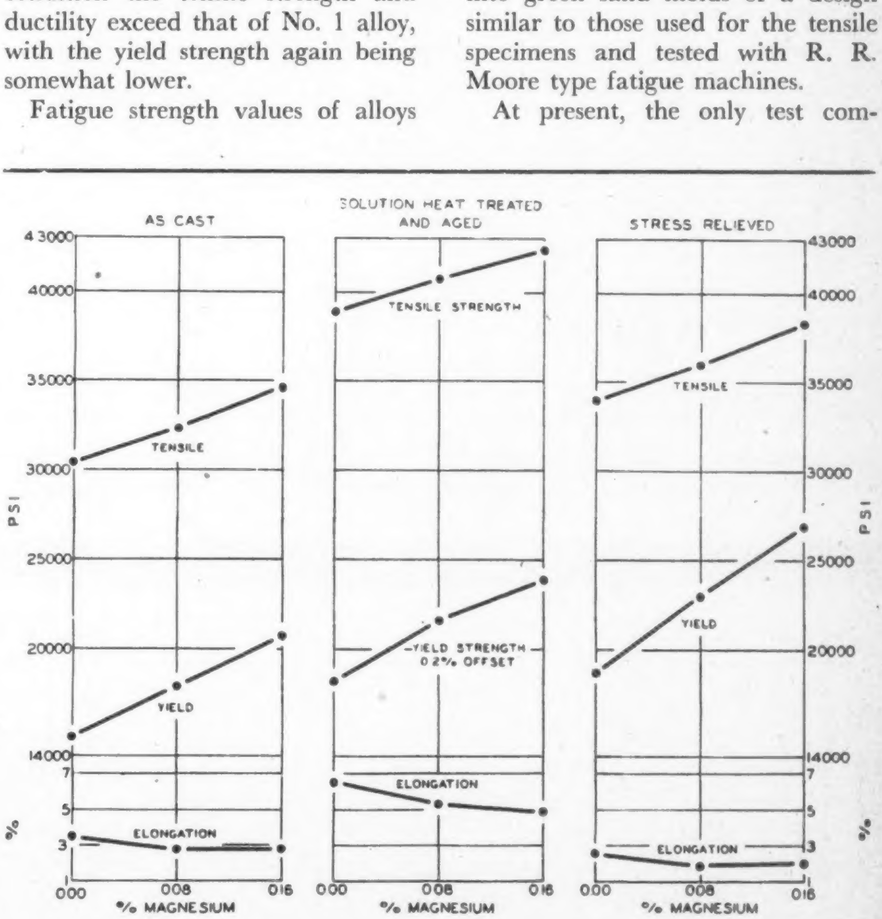
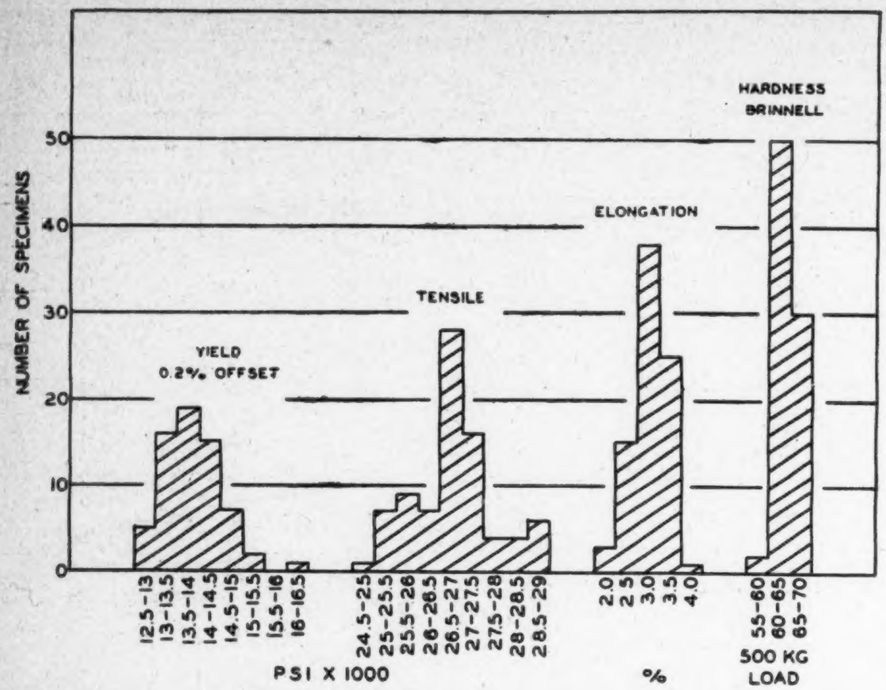
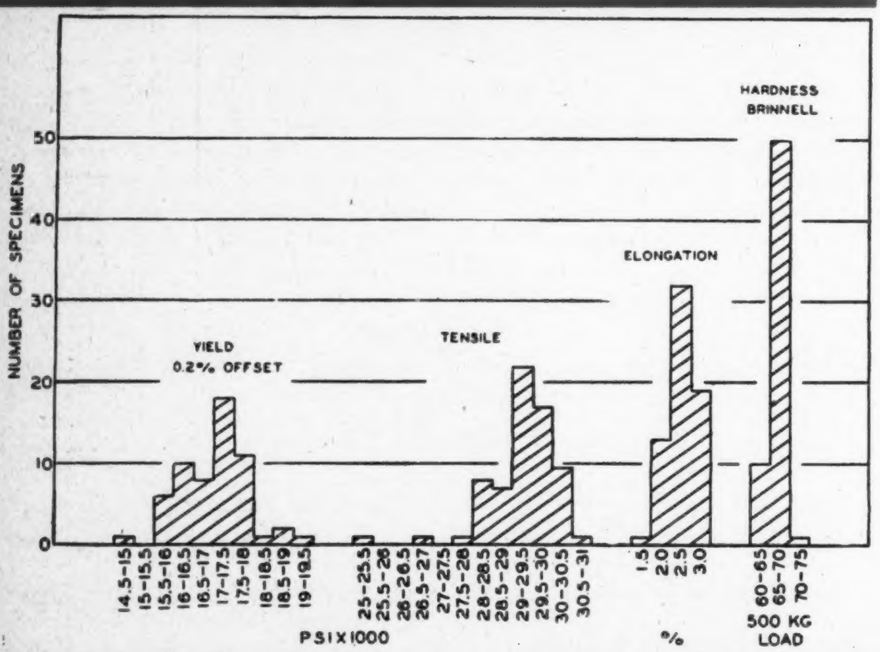
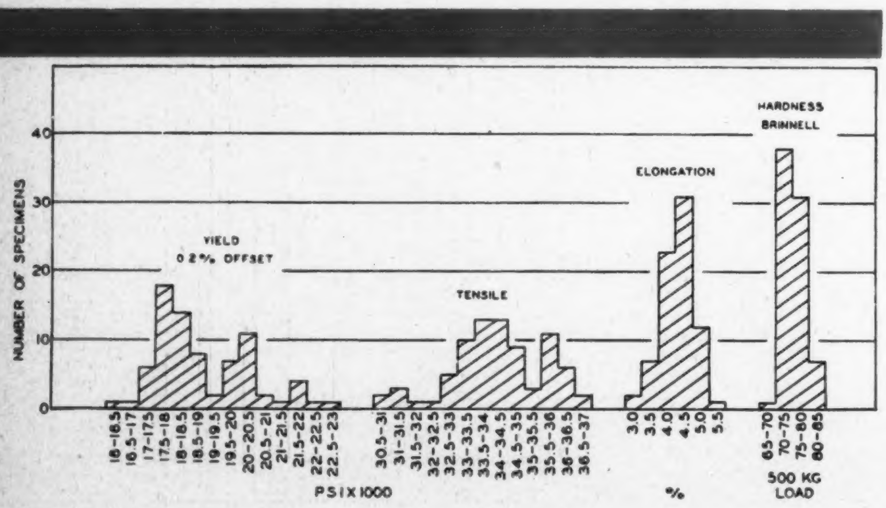


Fig. 5—Charts showing effect of magnesium on properties of chill-cast aluminum test specimens.







pleted was in the solution heat treated and aged condition. The results obtained, which are unusually high for this type of alloy, are given in Fig. 3. Indications of progressing tests are that the alloy also has a high fatigue strength under other conditions.

It is desirable to know some of the physical properties in some applications. A few of the results obtained are recorded in Table 4.

For some applications it is desirable to obtain higher values of the yield strength. As mentioned, this alloy is of the type in which the yield strength can easily be altered by small concentrations of magnesium, so an investigation of this type was made. A quite noticeable effect is obtained in the increase of the yield strength, with a somewhat lesser increase in tensile strength, while an appreciable amount of ductility still remains.

Data obtained from sand-cast specimens are shown in Figs. 4 and 5, respectively. The effect of magnesium on sand-cast impact specimens, machined to ASTM (E 23-41T) Type A Specifications, is shown in Fig. 6. As would be expected in cases where the ductility has been lowered, there is an accompanying drop in impact. In applications requiring higher impact value the magnesium content should be kept at a minimum, while applications requiring a higher yield strength should contain some magnesium.

Mechanical properties were checked on reverberatory heats of approximately 35,000 lb. to procure results expected in commercial practice. In Table 5 are recorded some results obtained from chill-cast specimens with a variation of magnesium content from 0.05 to 0.11 per cent.

Reading from top to bottom:

Fig. 7—Frequency distribution of properties of sand-cast aluminum alloy (as-cast, 13 heats).

Fig. 8—Frequency distribution of properties of sand-cast aluminum alloy (stress relieved, 13 heats).

Fig. 9—Solution heat treated and aged—13 heats. Frequency distribution of properties of sand-cast aluminum alloy.

Data secured from sand-cast specimens of 13 heats containing less than 0.02 per cent magnesium and nine heats containing 0.05 to 0.11 per cent magnesium are shown in Figs. 7 to 12. These data agree favorably with those of the preceding test.

Since composition is only a guide to the foundry trade for the type of alloy used, it should be considered as a problem secondary to such matters as casting technique, castability, and physical and mechanical properties. Therefore, the composition has not been mentioned in detail previously is now given in Table 6.

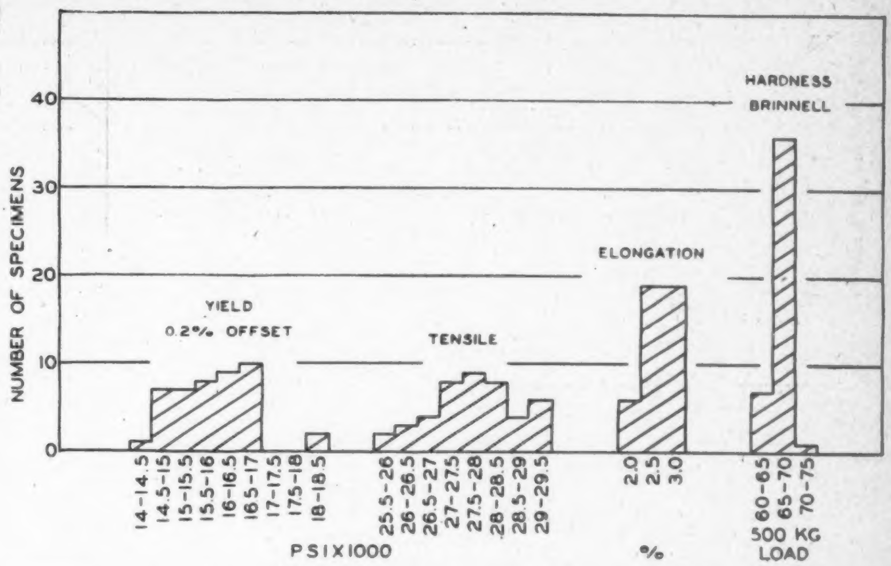
In summarizing, it may be said that, due to one of the latest methods for the recovery of airplane scrap, an excellent source of material is available at a reasonable cost for the production of alloys which can be utilized for several purposes. One such alloy has been discussed here. Alloys of this type, because of their good castability and properties, are general purpose alloys, and their usage could eliminate much of the confusion arising in foundries due to the segregation required when several alloys are cast.

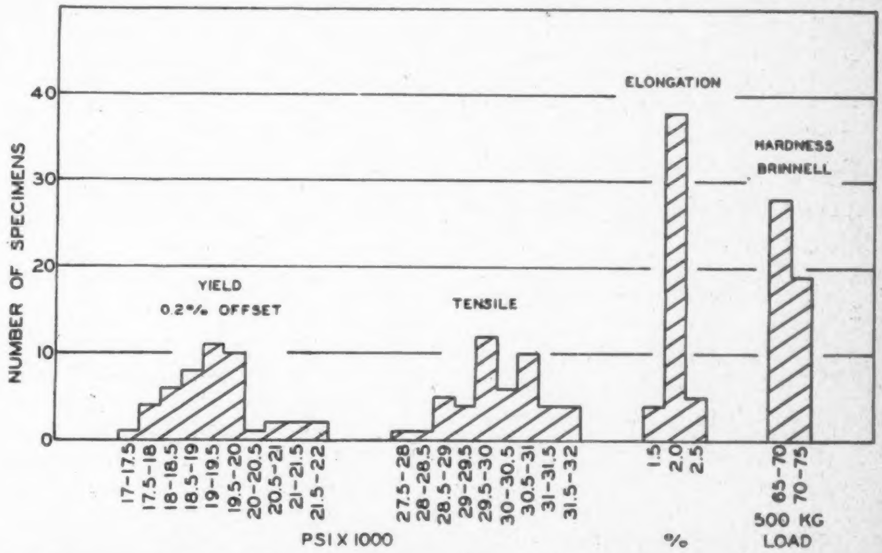
References

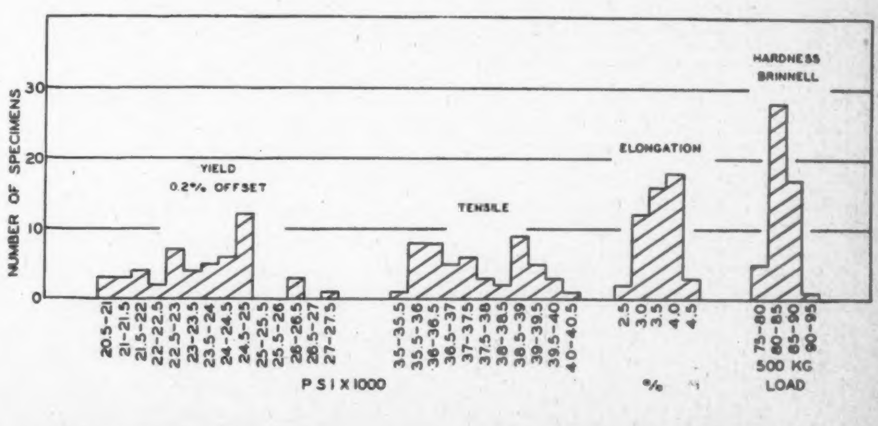
1. N. H. Engle, "The Influence of Scrap Aluminum on the Post-War Market," *Aluminum and Magnesium,* Nov., 1945, pp. 18.
2. E. J. Hardy, "Navy Disposal of Aircraft Scrap to Produce 15 Million Pounds of Secondary Metal," *The Iron Age,* Dec. 20, 1945, pp. 104.
3. "Aluminum in Aircraft," Aluminum Company of America, 1943.
4. W. Bonsack, "Effects of Minor Alloying Elements in Aluminum Casting Alloys," ASTM *Bulletin,* Aug., 1942.

DISCUSSION

Chairman: Walter Bonsack, National Smelting Co., Cleveland.







Reading from top to bottom:
Fig. 10—Sand-cast aluminum alloy—frequency distribution of properties. As-cast, 0.05-0.11 per cent Mg—9 heats.
Fig. 11—Stress relieved, 0.05-0.11 per cent Mg—9 heats. Frequency distribution of properties of sand-cast aluminum alloy.
Fig. 12—Solution heat treated and aged, 0.05-0.11 per cent Mg—9 heats. Frequency distribution of properties of sand-cast aluminum alloy.

Co-Chairman: L. W. EASTWOOD, Battelle Memorial Institute, Columbus, Ohio.

C. V. COOPER[1]: We have used this alloy and note that in the solution and aged condition the elongation is higher than in the solution treated condition only. Do you have any comments on this behavior?

MR. TICHY: We have no explanation for this behavior. We have also encountered this same thing as can be observed in Table A, which shows the average results of four to eight bars in each case.

[1]Acme Aluminum Alloys, Dayton, Ohio.

Table A

SOLUTION HEAT TREATED AND AGED

Yield Strength, 0.2% Offset, psi.	*Tensile Strength, psi.*	*Elongation, % in 2 in.*	*Brinell Hardness, 500-kg. load*	*Days Aged*	*Hours Aged*
AGED AT ROOM TEMPERATURE					
25400	37600	2.9	87	1	—
25500	37100	2.6	87	2	—
26300	37900	2.6	90	3	—
26100	38000	2.6	91	4	—
26500	38700	2.5	91	7	—
27200	38500	2.4	91	14	—
AGED AT 300° F.					
21800	35000	3.3	81	—	2
22400	35600	3.3	82	—	3
23000	36300	3.6	81	—	4
22200	35300	2.9	82	—	5
24800	37200	2.9	86	—	8
27300	38700	2.6	91	—	11
29400	39600	2.1	94	—	13
32100	41500	2.0	97	—	15

Reconversion Director Cites Castings Demand

CASTINGS in gray and malleable iron are of such vital importance in the national reconversion picture that the government is taking steps to relieve the critical merchant pig iron shortage which retards their production, John R. Steelman, Director of War Mobilization and Reconversion, indicated in the seventh report of that office, "At the Crossroads," issued in July.

Discussing pig iron, under key materials of production, and referring to the shortage for castings, Mr. Steelman reported that the Civilian Production Administration is arranging with Reconstruction Finance Corporation for reopening of blast furnaces owned by the Office of Defense Plants. Efforts to reopen certain privately owned furnaces, the Director noted, were set back with the lapse of OPA.

Shipment of Castings

Shipments of gray and malleable iron castings were at about the same level in May as in April; and output was 30 and 20 per cent, respectively, in the two alloys, above January but still somewhat short of the monthly average in the peak year of 1941. Rapid increase in the last half of 1946 is necessary if the critical shortage is to be overcome in the near future.

Report is comprised of two sections: Part One discusses price control, fiscal and monetary policy, production record, key materials of production and industrial relations; Part Two concerns special programs, contract settlement and functions of the advisory board to Mr. Steelman's office.

Foundry Appointees to Earn University Degree

CO-OPERATION between engineering schools and A.F.A. chapters is exemplified in a recent arrangement between the Wisconsin chapter and the University of Wisconsin, Madison. The University has asked the chapter to recommend young foundrymen for two salaried positions as assistants in the school foundry. Such employment would enable foundrymen appointed to work their way to a degree in the Department of Mining and Metallurgy; and would, at the same time, provide the students in the foundry with the benefits of advice out of a practical foundry background.

Death Ends Long Career Of William J. Coane

WILLIAM J. COANE, until his recent retirement vice-president, Ajax Metal Co., Philadelphia, died July 31, at the age of 79, after a long illness.

Associated with the foundry industry for more than 50 years, Mr. Coane was elected to Honorary Life Membership by the American Foundrymen's Association at its Golden Jubilee Convention in Cleveland. He had remained continuously active in the industry since the time when, as a member of the Philadelphia Foundrymen's Association, he took part in organization of A.F.A. at Philadelphia in 1896. In conferring Honorary Life Membership, the association cited his participation in that 1st Annual Convention and his long service.

William J. Coane

Native of Philadelphia, Mr. Coane attended Friends School and Central High School there, and began his career in the Philadelphia division of Joseph Dixon Crucible Co., Jersey City, N. J. After serving 26 years as manager of that division, he joined Ajax Metal Co. as vice-president, a position he held for the following 33 years. At the time of his death, he held the office of vice-president, C. Howard Hunt Pen Co., Camden, N. J.

Mr. Coane's contributions to business and community life won him wide admiration and confidence. Member of the executive committee, Non-Ferrous Ingot Metal Institute, Chicago, for 15 years, he represented that organization for many years as National Councillor in the Chamber of Commerce of U. S.

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Treasurer—C. S. Dold, Asst. Mgr., Coke Sales, Portsmouth Steel Corp., Cincinnati 2.
Assistant Treasurer—W. A. Funck, Gen. Supt., Aluminum Foundry Co., Cincinnati.
Directors—Terms Expire 1947
A. A. Alfers, Foundry Mgr., Oakley Pattern & Foundry Co., Cincinnati.
R. G. Ebersole, Dist. Mgr., Miller & Co., Cincinnati 2.
L. D. Fahey, Gen. Supt., Dayton Casting Co., Dayton, Ohio.
S. F. Levy, Met., Black-Clawson Co., Hamilton, Ohio.
H. F. McVay, President, Delhi Foundry Sand Co., Cincinnati.
A. W. Schneble, Sr., Sec.-Treas., The Advance Foundry Co., Dayton 3, Ohio.
Terms Expire 1948
Emil Albrecht, Treas., Aluminum Foundry Co., Cincinnati.
C. D. Steinmeir, Foundry Supt., A. D. Cook, Inc., Lawrenceburg, Ind.
Terms Expire 1949
G. A. Avril, G. A. Avril Smelting Works, Cincinnati.
C. H. Fredericks, Met., Cincinnati Milling Machine Co., Cincinnati.
Paul Ziegler, Gen. Mgr., H. P. Deuscher Co., Hamilton, Ohio.

Detroit Chapter

(Established 1935)

Chairman—A. H. Allen, Detroit Editor, Penton Publishing Co., Detroit 2.

Vice-Chairman—C. E. Silver, Works Mgr., Michigan Steel Casting Co., Detroit 7.

Secretary—R. E. Cleland, Dist. Repr., Eastern Clay Products, Inc., Detroit 26.

Treasurer—W. W. Bowring, Sales Engr., Frederic B. Stevens, Inc., Detroit 26.

Directors—Terms Expire 1947

O. L. Allen, Foundry Supt., Pontiac Motor Div., General Motors Corp., Pontiac, Mich.

G. C. Creusere, Foundry Met., Semet-Solvay Co., Detroit.

G. L. Galmish, Met., Michigan Malleable Iron Co., Detroit.

E. C. Hoenicke, Gen. Mgr., Foundry Div., Eaton Mfg. Co., Detroit 13.

J. E. Linabury, General Motors Corp., Pontiac, Mich.

Terms Expire 1948

J. P. Carritte, Jr., President, True Alloys, Inc., Detroit 9.

Ernest Lancashire, Chief Chemist, Detroit Steel Casting Co., Detroit 10.

R. G. McElwee, Mgr., Foundry Alloy Div., Vanadium Corp. of America, Detroit.

Gosta Vennerholm, Met., Ford Motor Co., Dearborn, Mich.

Terms Expire 1949

Pierce Boutin, Supt., Pontiac Motor Div., General Motors Corp., Pontiac, Mich.

E. J. Burke, Asst. Met., Hanna Furnace Corp., Detroit 26.

R. L. Orth, Sales Engr., American Foundry Equipment Co., Detroit 2.

W. N. Seese, Service Engr., J. S. McCormick Co., Detroit.

Eastern Canada and Newfoundland Chapter

(Established 1942)

Chairman—Henri Louette, Plant Supt., Warden King, Ltd., Montreal, Que.

Vice-Chairman—A. E. Cartwright, Canadian Foundry Supply & Equipment Co. Ltd., Montreal, Que.

Secretary—R. E. Cameron, Sec., Webster & Sons, Ltd., Montreal.

Treasurer—L. G. Guilmette, Sales and Serv., Canadian Foundry Supply & Equipment Co. Ltd., Montreal, Que.

Directors—Terms Expire 1947

A. C. Neal, Asst. Supt., Enamel Products & Heating, Ltd., Amherst, N. S.

G. D. Turnbull, Vice-Pres., Shawinigan Foundries Co. Ltd., Shawinigan Falls, Que.

O. L. Voisard, Supt., Robert Mitchell Co. Ltd., Montreal.

Terms Expire 1948

D. Allard, Asst. Dir., Arts and Crafts School, Provincial Government, Montreal, Que.

Harry Francis, Pattern Supt., Jenkins Bros., Montreal, Que.

E. Laurendeau, Partner, Canadian Pattern & Woodworking Co. Ltd., Montreal, Que.

R. Leclair, Foreman, Dominion Engineering Works, Ltd., Montreal, Que.

J. H. Newman, Sales and Service, Chamberlain Engineering (Canada), Ltd., Montreal, Que.

O. H. Seveigny, Gen. Mgr., Lynn, McLeod Metallurgy, Ltd., Thetford Mines, Que.

Robert Stott, Foreman, Canadian Car & Fdry. Co., Montreal.

Terms Expire 1949

W. L. Bond, Supt., Ottawa Car & Aircraft Co. Ltd., Ottawa, Ont.

C. C. Brisbois, Supt., Sorel Industries, Ltd., Sorel, Que.

W. J. Brown, Sales and Service, Robt. W. Bartram Co. Ltd., Montreal, Que.

W. M. Hamilton, Plant Mgr., Crane, Ltd., Montreal, Que.

John Shewan, Fdry. Supt., Canadian Car & Foundry Co.

Metropolitan Chapter

(Established 1938)

Chairman—H. L. Ullrich, Asst. Supt., Sacks-Barlow Foundries, Inc., Newark, N. J.

Vice-Chairman—K. A. DeLonge, Met., International Nickel Co. Inc., New York 5.

Secretary—J. F. Bauer, Salesman, Hickman, Williams & Co., New York 5.

Treasurer—D. Polderman, Jr., Vice-Pres. and Export Mgr., Whiting Corp., New York 6.

Directors—Terms Expire 1947

C. J. Law, Supt. Steel Foundries, Worthington Pump & Machinery Corp., Harrison, N. J.

A. B. McCullough, Vice-Pres., American Steel Castings Co., Newark 1, N. J.

W. E. Paulson, Pres., Thos. Paulson & Son, Inc., Brooklyn.

J. S. Vanick, Met., International Nickel Co., New York 5.

T. J. Wood, Supt., American Brake Shoe Co., Mahwah, N. J.

Terms Expire 1948

B. N. Ames, Jr., Met., U. S. Navy Yard, Brooklyn 13, N. Y.

B. E. Beldin, Whitehead Bros., New York.

Philip Van Duyne, The Meeker Foundry Co., Newark, N. J.

A. L. Fischer, Fischer Castings Co., Plainfield, N. J.

D. Frank O'Connor, Foundry Supt., American Saw Mill Machinery Co., Hackettstown, N. J.

Mexico City Chapter

(Established 1945)

President—Ing. Ernesto Villalobos, Gen. Mgr., Construccion y Maquinaria S. de R. L., Mexico, D.F.

Vice-President—Ing. Manuel Goicoechea, Gen. Mgr., Fundiciones de Hierro y Acero, S.A., Mexico, D.F.

Secretary—N. S. Covacevich, Owner, Casa Covacevich, Mexico, D.F.

Treasurer—Ing. F. G. Vargas, Met., Fundicion y Talleres America, S.A., Mexico, D.F.

Directors—Terms Expire 1947

Ing. Diego Castillo, Gen. Mgr., Maquinaria Mecanismos, Mexico, D.F.

Ing. Ricardo Memendez, Cia. Nacional de Clavos, Mexico, D.F.

F. G. Mena, Mgr., Menite Metals de Mexico, S.A., Mexico, D.F.

Ing. Secundino Ruiz, Supt., Hierro Maleable de Mexico, Mexico, D.F.

Ing. E. M. Sauza, Gen. Mgr., Fundicion y Talleres America S.A., Mexico, D.F.

John Schendel, Steel Div., Lo Consolidada, S.A., Mexico, D.F.

Michiana Chapter

(Established 1940)

Chairman—John McAntee, Foundry Mgr., Covel Mfg. Co., Benton Harbor, Mich.

Vice-Chairman—J. H. Miller, Supt., Josam Products Foundry Co., Michigan City, Ind.

Secretary-Treasurer—V. S. Spears, Sales Engr., American Foundry Equipment Co., Mishawaka, Ind.

Directors—Terms Expire 1947

Earl Byers, Time Study Engineer, Sibley Machine & Foundry Co., South Bend, Ind.

J. C. Manning, Foundry Supt., Clark Equipment Co., Buchanan, Mich.

K. A. Nelson, Branch Mgr., Chicago Hardware Foundry Co., Elkhart, Ind.

H. B. Voorhees, Asst. Foundry Supt., Dodge Mfg. Corp., Mishawaka, Ind.

Terms Expire 1948

J. E. Digan, President, Logansport Foundry Industries, Logansport, Ind.

G. O. McCray, Asst. Foreman, Bendix Products Div., Bendix Aviation Corp., South Bend, Ind.

John Rush, Supt., Elkhart Brass Mfg. Co., Elkhart, Ind.

M. F. Surls, Chief Met., Clark Equipment Co., Buchanan.

Terms Expire 1949

W. G. Ferrell, Gen. Wks. Supt., Auto Specialties Mfg. Co., St. Joseph, Mich.

G. E. Garvey, Pattern Foreman, City Pattern Works, South Bend, Ind.

S. F. Krzeszewski, Asst. to Vice-Pres., American Foundry Equipment Co., Mishawaka, Ind.

I. S. Peterson, Works Mgr., Premier Furnace Co., Dowagiac, Mich.

Northeastern Ohio Chapter

(Established 1935)

President—H. J. Trenkamp, President, The Ohio Foundry Co., Cleveland 6.
Vice-President—Bruce Aiken, Supt., Crucible Steel Casting Co., Cleveland 2.
Secretary—G. J. Nock, Treas., The Nock Fire Brick Co., Cleveland 14.
Treasurer—F. Ray Fleig, President, Smith Facing & Supply Co., Cleveland 13.
Directors—Terms Expire 1947
A. C. Denison, President, Fulton Foundry & Machine Co., Cleveland 4.
J. E. Dvorak, Met., Eberhard Mfg. Co., Cleveland 4.
B. S. Parker, Jr., Youngstown Foundry & Machine Co., Youngstown, Ohio.
Frank Weisehan, Met., Ferro Machine & Foundry Co., Cleveland 4.
Paul Wheeler, Sales Rep., Link-Belt Co., Cleveland 13.
Elmer Zirzow, Met., National Malleable & Steel Castings Co., Cleveland 6.
Terms Expire 1948
F. C. Cech, Teacher, Cleveland Trade School, Cleveland 15.
David Clark, Asst. Plant Mgr., Forest City Foundries Co., Cleveland 13.
E. J. Metzger, Plant Mgr., Wellman Bronze & Aluminum Co., Cleveland 6.
L. F. Miller, Sales Rep., Osborn Mfg. Co., Cleveland 14.
T. D. West, Vice-Pres., West Steel Casting Co., Cleveland 3.
Terms Expire 1949
W. G. Gude, Managing Editor, *The Foundry*, Cleveland 13.
Fred Pfarr, Plant Mgr., Lake City Malleable Co., Cleveland 14.
V. J. Sedlon, President, Master Pattern Co., Cleveland 13.
W. E. Sicha, Met., Aluminum Co. of America, Cleveland 5.
C. S. Winter, President, Duplex Mfg. & Foundry Co., Elyria, Ohio.

Northern California Chapter

(Established 1935)

President—Richard Vosbrink, Owner, Berkeley Pattern Works, Berkeley, Calif.
Vice-President—A. M. Ondreyco, Plant Mgr., Vulcan Foundry Co., Oakland, Calif.
Secretary—J. F. Aicher, Dist. Mgr., E. A. Wilcox Co., San Francisco.
Co-Secretary—Charles Marshall, Dist. Mgr., Chamberlain Co., Oakland 4, Calif.
Treasurer—J. K. Benedict, Owner, Donald Kenneth Co., San Francisco.
Directors—Terms Expire 1947
A. C. Axford, Mgr., Mission Foundry & Stove Works, San Francisco.
Norman Barnett, Foundry Supt., M. Greenburg's Sons, San Francisco 7.
R. C. Noah, Mgr., San Francisco Iron Foundry, San Francisco.
G. W. Penning, Mgr., Enterprise Engine & Foundry Co., San Francisco.
Terms Expire 1948
Leon Cameto, Owner, Production Foundry Co., Oakland, Calif.
W. W. Clark, Met., Enterprise Engine & Foundry Co., San Francisco.
H. M. Donaldson, Partner, Brumely-Donaldson Co., San Francisco.
F. T. Williams, Vice-Pres., Empire Foundry Co., Oakland 7, Calif.

Northern Illinois and Southern Wisconsin Chapter

(Established 1938)

Chairman—John Doerfner, Jr., Chief Engr., Gunite Foundries Corp., Rockford, Ill.
Vice-Chairman—John Clausen, Foundry Engr., Greenlee Bros. & Co., Rockford, Ill.
Secretary—H. J. Bauman, Foundry Supt., Ebaloy, Inc., Rockford, Ill.
Treasurer—Lester Fill, Foundry Supt., George D. Roper Corp., Rockford, Ill.
Directors—Terms Expire 1947
R. D. Baysinger, President, Iron Star Foundry Co., Rockford, Ill.
R. J. Looze, Brass Foundry Foreman, Beloit Iron Works, Beloit, Wis.
A. P. Rose, Foundry Supt., National Sewing Machine Co., Belvidere, Ill.
Terms Expire 1948
Gunnard Johnson, Met., Beloit Iron Works, Beloit, Wis.
J. N. Johnson, Asst. Wks. Supt., J. I. Case Co., Rockford, Ill.
R. W. Mattison, Vice-Pres., Mattison Machine Works, Rockford, Ill.
Terms Expire 1949
J. R. Cochran, Met., Sundstrand Machine Tool Co., Foundry Div., Rockford, Ill.
J. A. Forbes, Exec. Vice-Pres. and Gen. Mgr., Gunite Foundries Corp., Rockford, Ill.

Northwestern Pennsylvania Chapter

(Established 1945)

Chairman—E. M. Strick, Finishing Supt., Erie Malleable Iron Co., Erie.
Vice-Chairman—J. W. Clarke, Asst. Supt. of Foundries, General Electric Co., Erie.
Secretary—H. L. Gebhardt, President, United Oil Mfg. Co., Erie.
Treasurer—D. J. James, Supt., Cooper-Bessemer Corp., Grove City, Pa.
Directors—Terms Expire 1947
R. D. Carver, Foundry Supt., Standard Stoker Co., Erie.
R. W. Griswold, Jr., Vice-Pres., Griswold Mfg. Co., Erie.
J. S. Hornstein, Mgr. and Secy., Meadville Malleable Iron Co., Meadville, Pa.
W. J. Miller, Serv. Engr., Frederic B. Stevens, Inc., Erie.
Terms Expire 1948
T. H. Beaulac, Foundry Supt., Chicago Pneumatic Tool Co., Franklin, Pa.
F. J. Eisert, Partner, Urick Foundry Co., Erie.
C. H. Fitz, Foundry Supt., Hays Mfg. Co., Erie.

Ontario Chapter

(Established 1938)

Chairman—J. A. Wotherspoon, Gen. Mgr., Imperial Iron Corp., Ltd., St. Catharines, Ont.
Vice-Chairman—J. Dalby, Mgr., Wilson Brass & Aluminum Foundries, Toronto, Ont.
Secretary-Treasurer—G. L. White, Editor, Westman Publications, Ltd., Toronto, Ont.
Directors—Terms Expire 1947
T. D. Barnes, Sales Mgr., Don Barnes Foundry Supplies & Equipment, Hamilton, Ont.
L. B. Morris, Works Mgr., Gurney Foundry Co. Ltd., Toronto, Ont.
R. T. Wilson, Asst. Plant Supt., Malleable Iron Co. Ltd., Oshawa, Ont.
R. A. Woods, Repr., George F. Pettinos (Canada), Ltd., Hamilton, Ont.
Terms Expire 1948
H. E. Craddock, Supt., Beatty Bros., Ltd., London, Ont.
D. H. Gilbert, Plant Mgr., Dominion Wheel & Foundries, Ltd., St. Boniface, Manitoba.
J. H. King, Sales Repr., Werner G. Smith, Ltd., Toronto, Ont.
E. G. Storie, Plant Supt., Fittings, Ltd., Oshawa, Ont.
Terms Expire 1949
C. O. Flowers, Supt., Canada Iron Foundries, Ltd., Hamilton, Ont.
J. H. McNulty, Canada Electric Steel Casting, Ltd., Orillia, Ont.
M. N. Tallman, Met., A. H. Tallman Bronze Co. Ltd., Hamilton, Ont.

Oregon Chapter

(Established 1945)

Chairman—W. R. Pindell, Mgr., Northwest Foundry & Furnace Works, Inc., Portland 2.

Vice Chairman—H. L. Tatham, Supt., Pacific Steel Foundry Co., Portland 9.

Secretary-Treasurer—F. A. Stephenson, Partner, Dependable Pattern Works, Portland 14.

Directors—Terms Expire 1947

D. H. L. Bealer, Supt., American Brake Shoe Co., Portland 9.

A. J. Grbavac, Supt., Columbia Steel Casting Co., Portland 13.

F. A. Stephenson, Partner, Dependable Pattern Works.

Terms Expire 1948

S. E. Peeler, Supt., Electric Steel Casting Co., Portland 10.

W. R. Pindell, Mgr., Northwest Foundry & Furnace Works.

A. R. Prier, Vice-Pres., Oregon Brass Works, Portland 14.

Terms Expire 1949

L. E. Bufton, Partner, Silica Products of Oregon, Ltd., Portland 4.

A. B. Holmes, Supt., Crawford & Doherty Foundry Co., Portland 2.

H. L. Tatham, Supt., Pacific Steel Foundry Co., Portland 9.

Philadelphia Chapter

(Established 1935)

Chairman—B. A. Miller, Supt., Cramp Brass & Iron Foundries Div., Baldwin Locomotive Works, Philadelphia 42.

Vice-Chairman—E. C. Troy, Chief Met., Dodge Steel Corp., Philadelphia 35.

Secretary-Treasurer—W. B. Coleman, President, W. B. Coleman & Co., Philadelphia 40.

Directors—Terms Expire 1947

C. L. Lane, Met., Florence Pipe & Machine Co., Florence, N. J.

J. M. Robb, Jr., Resident Mgr., Hickman, Williams & Co., Philadelphia 2.

H. V. Witherington, H. W. Butterworth & Sons Co., Bethayres, Pa.

Terms Expire 1948

Earl Eastburn, Foundry Supt., Phosphor Bronze Smelting Co., Philadelphia 46.

H. E. Mandel, Vice-Pres., Pennsylvania Foundry Supply & Sand Co., Philadelphia 24.

Terms Expire 1949

A. C. Gocher, Foundry Supt., Fletcher Works, Inc., Philadelphia 40.

W. Morley, Foundry Mgr., Link-Belt Co., Olney Foundry Div., Philadelphia 20.

Quad City Chapter

(Established 1935)

Chairman—C. S. Humphrey, Owner, C. S. Humphrey Co., Moline, Ill.

Vice-Chairman—Russell Schwartz, President, Ferro-Bronze Corp., Moline, Ill.

Secretary-Treasurer—C. R. Marthens, Owner, Marthens Co., Moline, Ill.

Directors—Terms Expire 1947

W. E. Jones, American Steel Foundries, Bettendorf, Iowa.

A. W. Pietz, Vice-Pres. and Foundry Mgr., Iowa Steel & Iron Co., Cedar Rapids, Iowa.

A. H. Putnam, Consulting Met., A. H. Putnam Co., Rock Island, Ill.

Terms Expire 1948

J. Nelson, Supt., Mississippi Foundry Co., Rock Island, Ill.

R. E. Wilke, Testing and Research Lab., Deere & Co., Moline, Ill.

Terms Expire 1949

Martin Liedke, Foundry Supt., International Harvester Works, Rock Island. Ill.

Carl Von Luhrte, Sales Engr., Chicago Retort & Fire Brick Co., Chicago, Ill.

A. D. Mathison, Works Mgr., French & Hecht Co., Davenport, Iowa.

Rochester Chapter

(Established 1944)

President—W. G. Brayer, Foundry Supt., Bausch & Lomb Optical Co., Rochester.

Vice-President—L. C. Gleason, Foundry Engr., Gleason Works, Rochester.

Secretary-Treasurer—L. C. Kimpal, Industrial Engr., Rochester Gas & Electric Corp., Rochester 4.

Directors—Terms Expire 1947

M. T. Ganzauge, Foundry Supt., General Railway Signal Co., Rochester.

H. B. Hanley, Foundry Mgr., American Laundry Machinery Co., Rochester.

W. F. Morton, Works Mgr., Anstice Co., Rochester.

Terms Expire 1948

D. D. Baxter, Rep., Sterling Wheelbarrow Co., Rochester.

N. F. Clement, Vice-Pres., Rochester-Erie Foundry Corp., Rochester.

D. E. Webster, Met., American Laundry Machinery Co.

Terms Expire 1949

H. G. Hetzler, President, Hetzler Foundries, Inc., Rochester.

C. B. Johnson, Asst. to Works Mgr., Symington-Gould Corp., Rochester.

J. E. McHenry, Supt. of Foundry, Gleason Works.

Saginaw Valley Chapter

(Established 1945)

Chairman—J. F. Smith, Gen. Supt., Chevrolet Grey Iron Foundry Div., General Motors Corp., Saginaw, Mich.

Vice-Chairman—M. V. Chamberlin, Met., Dow Chemical Co., Bay City, Mich.

Secretary-Treasurer—F. S. Brewster, Met., Dow Chemical Co. Bay City, Mich.

Directors—Terms Expire 1947

J. J. Clark, Asst. Met., Saginaw Malleable Iron Div. General Motors Corp., Saginaw, Mich.

Charles Morrison, Met., Saginaw Malleable Iron Div., General Motors Corp., Saginaw, Mich.

O. E. Sunstedt, Gen. Mgr., General Fdry. Co., Flint, Mich.

C. A. Tobias, Head, Science Dept., General Motors Institute of Technology, Flint, Mich.

Terms Expire 1948

E. H. Bankard, Asst. Supt., Buick Motor Div., General Motors Corp., Flint, Mich.

J. E. Bowen, Met., Chevrolet Grey Iron Foundry Div., General Motors Corp., Saginaw, Mich.

K. H. Priestley, President, Vassar Electroloy Products, Vassar, Mich.

Terms Expire 1949

D. D. Bowman, Office Mgr., Almont Mfg. Co., Almont, Mich.

L. L. Clark, Plant Met., Buick Motor Div., General Motors Corp., Flint, Mich.

L. A. Cline, Secy., Saginaw Foundries Co., Saginaw, Mich.

St. Louis District Chapter

(Established 1935)

Chairman—R. T. Leisk, Asst. Works Mgr., American Steel Foundries, East St. Louis, Ill.

Vice-Chairman—N. L. Peukert, Carondelet Foundry Co., St Louis.

Secretary—R. E. Woods, Treas., Warren Coke Co., St. Louis 1.

Treasurer—H. W. Wiese, Sales Engr., St. Louis 8.

Directors—Terms Expire 1947

L. A. Kleber, Foundry Supt., General Steel Castings Corp., Granite City, Ill.

F. B. Riggan, Chief Met., Key Co., East St. Louis, Ill.

C. H. J. Walcher, Works Mgr., American Steel Foundries, Granite City, Ill.

J. H. Williamson, Salesman, M. A. Bell Co., St. Louis.

Terms Expire 1948

E. E. Ballard, Plant Mgr., National Bearing Div., American Brake Shoe Co., St. Louis.

J. R. Bodine, Pres., Bodine Pattern & Fdry. Co., St. Louis.

(Continued on Page 88)

★ NEW A. F. A. MEMBERS ★

(Covering the period from July 1 to August 15)

• Although many chapter activities are suspended during the summer months, the work of the chapter membership committees continues the year around. On these pages are listed 145 new members, contributed through the combined efforts of twenty-eight chapter membership committees. Southern California led the list of new members with 14, while Cincinnati and Metropolitan were next in line with 11 and 9, respectively. Foreign memberships continue to come into the National Office from such far off places as Malaya and Tasmania.

BIRMINGHAM DISTRICT CHAPTER

E. V. Camp, Pres., E. V. Camp & Associates, Inc., Atlanta, Ga.
Donald E. Matthieu, Met., Stockham Pipe Fittings Co., Birmingham, Ala.
Hal F. Mosley, Fdry. Foreman, Mooresville Iron Works, Mooresville, N. C.
E. A. Rowell, V. P., Tornado Supply Co., Anniston, Ala.
R. Barron Storms, Pres., Tornado Supply Co., Anniston, Ala.

CANTON DISTRICT CHAPTER

W. S. Brunkhurst, Quality Engr., Pitcairn Co., Pittsburgh Valve & Fittings Div., Barberton, Ohio.
***National Rubber Machinery Co., Columbiana, Ohio (G. R. Bilger, Plant Mgr.).**

CENTRAL INDIANA CHAPTER

Russell Chadwell, Fore., Hoosier Iron Works, Kokomo, Ind.
Donald Getz, Fore., Hoosier Iron Works, Kokomo, Ind.
Fred Martin, Fore., Hoosier Iron Works, Kokomo, Ind.
F. R. McDuffic, Fore., Fountain Foundry Corp., Veedersburg, Ind.
Walter Schmidt, Fore., Hoosier Iron Works, Kokomo, Ind.

CENTRAL NEW YORK CHAPTER

Thomas F. Jones, Pres., Oswego Iron Works, Inc., Oswego, N. Y.
L. A. LaVine, Gen. Fore., Core Dept., New York Air Brake Co., Watertown, N. Y.

CENTRAL OHIO CHAPTER

Harry Frese, Supt., Ohio Stove Co., Portsmouth, Ohio.
James B. Miller, V. Treas., Ohio Stove Co., Portsmouth, Ohio.
Frank Schneider, Fore., Jeffrey Mfg. Co., Columbus, Ohio.

CHESAPEAKE CHAPTER

Thomas P. Gunter, Asst. Cupola Fore., Lynchburg Foundry Co., Lynchburg, Va.

CHICAGO CHAPTER

Richard J. Brown, Edw. S. Christiansen Co., Chicago.
B. R. Hitpas, Fdry. Engr., E. F. Houghton & Co., Elmhurst, Ill.
***Harry W. Leighton Co., Chicago (Harry W. Leighton, Gen. Mgr.).**
A. T. March, Met., Western Electric Co., Chicago.
John Smith, Jr., Met. Engr., Western Electric Co., Chicago.
Ralph W. Swanson, Apprentice, Swanson Pattern & Model Works, East Chicago, Ind.

CINCINNATI DISTRICT CHAPTER

Alexander D. Barczak, V.P., Bardes Forge & Foundry Co., Cincinnati.
Earl Beyerlein, Hart Mfg. Co., Louisville, Ky.
Ben C. Booher, Fore., Bardes Forge & Foundry Co., Cincinnati.
Vernon L. Ferrier, Mold. Fore., Bardes Forge & Foundry Co., Cincinnati.
George T. Keller, Plant Engr., Bardes Forge & Foundry Co., Cincinnati.
Samuel T. Korte, Sales Repr., R. Lavin & Sons, Inc., Chicago.
Margaret Spellacy, Chief Chem., Dayton Steel Foundry Co., Dayton, Ohio.
Edgar O. Stamm, Repr., Socony-Vacuum Oil Co., Inc., Certified Core Oil Div., Cicero, Ill.
Clarence J. Stewart, Fdry. Mgr., Bardes Forge & Foundry Co., Cincinnati.
Ernest J. Stockum, V. P., Dayton Malleable Iron Co., Dayton, Ohio.
Charles R. Taylor, Supv. Met., The American Rolling Mill Co., Middletown, Ohio.

DETROIT CHAPTER

William A. Abernathy, Sales, Carl A. Underhill & Co., Detroit.
Richard E. Jacobs, Field Engr., Whiting Corp., Detroit.
Starr L. Klino, Fore., Ford Motor Co., Dearborn, Mich.

*Company Members.

EASTERN CANADA & NEWFOUNDLAND CHAPTER

R. Rousseau, Molder, Megantic Foundry, Lac Megantic, Que.

METROPOLITAN CHAPTER

William T. Bourke, Plant Met., American Brake Shoe Co., Mahwah, N. J.
J. Brax, Tech. Adv., Trade Commission of Finland, New York.
James E. Chafey, Associate Met., Columbia University, New York.
Herbert E. Cragin, Jr., Plant Supt., Taylor Wharton Iron & Steel Co., High Bridge, N. J.
***New Hampshire Forge & Foundry Corp., Salmon Falls, N. H. (F. L. Hill, Pres.).**
Jesse Huckert, Asst. Editor, *Product Engineering*, New York.
Henry Macler, Met., The Singer Mfg. Co., Elizabeth, N. J.
Frank A. Park, Fdry. Engr., The Singer Mfg. Co., Elizabeth, N. J.
Fenimore B. Zelley, Worthington Pump & Machinery Co., Harrison, N. J.

MEXICO CITY CHAPTER

Cerendo Ferrevch, Magninaria y Mecanismos S.A., Mexico D. F.

MICHIANA CHAPTER

Edwin F. Rhodes, Spec. Proj. Engr., Dodge Mfg. Corp., Mishawaka, Ind.
W. A. Russell, Supt., Benton Harbor Malleable Co., Benton Harbor, Mich.

NORTHEASTERN OHIO CHAPTER

R. O. Anderson, Supt., National Tube Company, Lorain, Ohio.
***Bellville Foundries, Inc., Bellville, Ohio (Michael C. Rose, Pres.).**
E. R. Brennan, Met. Engr., Ferro Machine & Foundry Co., Cleveland.
H. L. Buckingham, Supt., Anchor Foundry Co., Bedford, Ohio.
Thomas W. Gallagher, Pers. Dir., Lake City Malleable Co., Cleveland.
John D. Senuta, Asst. Supt. Core Room, Ferro Machine & Foundry Co.
***V. L. Smithers Laboratories, Akron, Ohio (V. L. Smithers, Pres.).**
George H. Woodworth, Mfg. Engr., Westinghouse Electric Corp., Trafford, Pa.

NORTHERN CALIFORNIA CHAPTER

Richard C. Nelson, Insp., Pacific Steel Casting Co., Berkeley, Calif.
George Jules Vergne, Owner, Richmond Ornamental Brass & Aluminum Foundry, Richmond, Calif.

NO. ILLINOIS & SO. WISCONSIN CHAPTER

***Yates American Machine Co., Beloit, Wis. (W. D. Johnson, Works Mgr.).**

NORTHWESTERN PENNSYLVANIA CHAPTER

J. W. Convidnie, Jr., General Electric Co., Erie, Pa.
***Erie Malleable Iron Co., Erie, Pa. (P. H. Vincent, Gen. Mgr.).**

ONTARIO CHAPTER

Ross L. Bullock, Asst. Foundry Supt., Fittings Ltd., Oshawa, Ont.
W. J. Cameron, Supt., Anthes Foundry Ltd., Winnipeg, Manitoba.
Chief Supt. of Arsenal, Quebec City, P. Q.

OREGON CHAPTER

Kenneth R. Carrell, Sales, R. Hoe & Co., Inc., Portland, Ore.
J. H. Getman, Fdry. Supt., N. W. Foundry & Furnace Co., Portland, Ore.
W. M. Hippler, Owner, Peninsula Pattern Works, Portland, Ore.
Dale F. Spikes, Fore., Pacific Steel Foundry, Portland, Ore.
George C. Tolton, Dist. Repr., American Foundry Equipment Co., Mishawaka, Ind.
George C. Vann, Asst. Mgr., N. W. Foundry & Furnace Co., Portland, Ore.

PHILADELPHIA CHAPTER

George Allen, Glassboro, N. J.
***The George Sall Metals Co., Philadelphia (George L. Sall, Partner).**
James H. Walsh, Furnace Fore., Bethlehem Steel Co., Bethlehem, Pa.

ROCHESTER CHAPTER

Joseph E. Sansig, Abrasive Eng., Cross Bros. Co. Inc., Rochester, N. Y.

SAGINAW VALLEY CHAPTER

Kenneth Loer, Serv. Engr., Kuhlman Electric Co., Bay City, Mich.

ST. LOUIS DISTRICT CHAPTER

Henry P. Bentrup, Supt., Carondelet Foundry Co., St. Louis, Mo.

Lloyd C. Farquhar, Jr., East St. Louis Castings Co., East St. Louis, Ill.
Ernest W. Strauch, Foreman, U. S. Radiator Co., Edwardsville, Ill.

SOUTHERN CALIFORNIA CHAPTER

E. V. Akerlow, Fdry. Engr., Fairbanks Works, Pomona, Calif.
Harry M. Bayly, Sales Mgr., Pacific Abrasive Supply Co., Los Angeles.
Edward B. Carroll, Sale Engr., Pacific Abrasive Supply Co., Los Angeles.
George B. Cottrell, Partner, Cottrell Casting Co., North Long Beach, Calif.
James A. Cottrell, Jr., Partner, Cottrell Casting Co., North Long Beach, Calif.
J. A. DeCelle, Fdry. Engr., Howell Foundry Co., Inc., Los Nietos, Calif.
J. M. East, Serv. Engr., Independent Pneumatic Tool Co., Los Angeles.
M. E. Hascal, Owner, Sheco, Los Angeles.
Joe Hollingshead, Asst. Fore., Enterprise Iron Works, Los Angeles.
W. H. Merry, Plant Mgr., Eljer Co. of California, Los Angeles.
Stephen H. Sims, Molder, Cottrell Casting Co., North Long Beach, Calif.
George F. Slabodnik, Owner, Sheco, Los Angeles.
Ernest G. Snyder, Owner, Ramona Foundry, Los Angeles.
Warren E. Tracy, Owner, Lynwood Iron Works, Lynwood, Calif.

TEXAS CHAPTER

E. W. Glenney, Owner, Glenney Pattern Works, San Antonio, Texas.
***Jaques Power Saw & Steel Co., Mineral Wells, Texas (Byron B. McCroskey, Mgr.).**
A. G. Wallace, Salesman, Acme Brick Co., Houston, Texas.

TWIN CITY CHAPTER

Leslie Alexander, Fore., Mold. Dept., Minneapolis Electric Steel Castings Co., Minneapolis.
Carter DeLaittre, Foreman, Minneapolis Electric Steel Castings Co., Minneapolis.
Walter Hastings, Fore., Diamond Iron Works, Minneapolis.
Clarence R. Johnson, Supt., Continental Foundries, Inc., Albert Lea, Minn.
E. L. Shaughnessy, Met., Werner G. Smith Co., Minneapolis.
Francis E. Valley, Student, The Stout Institute, Menomonie, Wis.

WESTERN MICHIGAN CHAPTER

R. J. Bell, Plant Met., Newaygo Engineering Co., Newaygo, Mich.
Rudolph Grahek, Fore., Cadillac Malleable Iron Co., Cadillac, Mich.
William Little, Fore., Cadillac Malleable Iron Co., Cadillac, Mich.
Reuben Soderquist, Fore., Cadilac Malleable Iron Co., Cadillac, Mich.
Isaac Vander Vlucht, Fore., Cadillac Malleable Iron Co., Cadillac, Mich.

WISCONSIN CHAPTER

Roy Bellin, Grede Foundries, Inc., Milwaukee.
Roger Haberman, Trainee, Grede Foundries, Inc., Milwaukee.
Stewart Hagen, Trainee, Grede Foundries, Inc., Milwaukee.
Burleigh Jacobs, Jr., Trainee, Grede Foundries, Inc., Milwaukee.
O. George Specht, Trainee, Grede Foundries, Inc., Milwaukee.
Robert van Bereghy, Trainee, Grede Foundries, Inc., Milwaukee.
Leslie Woehlke, Trainee, Grede Foundries, Inc., Milwaukee.

OUTSIDE OF CHAPTER

Clifford Boyd, Mold. Fore., Oklahoma Steel Castings Co., Tulsa, Okla.
T. A. Bright, Qtrm. Molder, U. S. Naval Shipyard, Bremerton, Wash.
Calvin Dunham, Mold. Fore., Oklahoma Steel Castings Co., Tulsa, Okla.
Otto French, Core Rm. Fore., Oklahoma Steel Castings Co., Tulsa, Okla.
John Gault, Clean. Rm. Fore., Oklahoma Steel Castings Co., Tulsa, Okla.
W. C. Hackbarth, Prod. Mgr., Oklahoma Steel Castings Co., Tulsa, Okla.
Dale Hall, Met., Oklahoma Steel Castings Co., Tulsa, Okla.
Hilbert Hibbs, Mold. Fore., Oklahoma Steel Castings Co., Tulsa, Okla.
Adolph Hugo, Fore., Electric Maintenance, Oklahoma Steel Castings Co., Tulsa, Okla.
Frank Madrigal, Gen. Mold. Fore., Oklahoma Steel Castings Co., Tulsa, Okla.
Don McArthur, Insp., Oklahoma Steel Castings Co., Tulsa, Oklahoma.
Edward J. McAfee, Master Patternmaker., Puget Sound Naval Shipyard, Bremerton, Wash.
Frank Newberry, Clean. Rm. Fore., Oklahoma Steel Castings Co., Tulsa, Okla.
Alfonso Ospina, Field Engr., Pittsburgh Lectromelt Furnace Corp., Pittsburgh, Pa.
Howard Peck, Master Mech., Oklahoma Steel Castings Co., Tulsa, Okla.
Frank Scaggs, Clean. Rm. Fore., Oklahoma Steel Castings Co., Tulsa, Okla.
Harold R. Wolder, Ldgm. Molder, Foundry, Puget Sound Naval Shipyard, Bremerton, Wash.

Denmark

Arnold Busck, Kjobmagergade 49, Copenhagen.

England

***F. H. Loyd & Co., Ltd., Wednesbury, Staffs.**
Tsun Chang Tsung, Hadfields Ltd., Sheffield.

France

Georges Bouchot, Mgr., Schneider & Co., Le Creusot.
Raymond Depoux, Gen. Mgr., Societe Metallurgigue & Aubquives Villerupt, Villerupt.
C. M. Ventre, Gen. Mgr., Acieries D'Hirson, Paris.

Holland

F. W. E. Spies, Gen. Mgr., Nieuwe Schulpweg F 9, Velsen Noordpost Beverwijk.
J. H. Ubbink, Mgr. Dir., N.V.B. Ubbink & Co., Yzergietery, Doesburg.

Malaya

Foo Seik Kai, Mgr., Kwong Thoong Fatt Foundry, Perak (Via Singapore).

South Africa

African Malleable Foundries Ltd., Benoni, Transvaal.

South America

Enrique E. Cavada, Lt. Comdr., Chilean Navy, Talcahuano, Chile.

Tasmania

F. McCormick, Mgr., The EMU Bay Railway Co. Ltd., Burnie.

*Company Members.

CHAPTER DIRECTORY

(Continued from Page 86)

R. M. Hill, Jr., Treas. and Supt., East St. Louis Castings Co., East St. Louis, Ill.
Herman Weible, Foundry Supt., Maco Foundry & Enamel Shop, St. Louis.

Terms Expire 1949

J. E. Holtman, Works Mgr., American Manganese Steel Div., American Brake Shoe Co., St. Louis.
L. H. Horneyer, Lee H. Horneyer Co., St. Louis 3.
W. E. Illig, Vice-Pres., Banner Iron Works, St. Louis 10.
Charles Rothweiler, Salesman, Hickman, Williams & Co., St. Louis 1.

Southern California Chapter

(Established 1937)

President—W. D. Emmett, Foreman, Los Angeles Steel Casting Co., Los Angeles 11.
Vice-President—H. E. Russill, Vice-Pres., Eld Metal Co. Ltd., Los Angeles 1.
Secretary—L. O. Hoffstetter, Brumley-Donaldson Co., Los Angeles 11.
Treasurer—E. D. Shomaker, Pattern Shop Foreman, Kay-Brunner Steel Products, Inc., Alhambra, Calif.
Directors—Terms Expire 1947

V. P. Barton, Vice-Pres., Triplett & Barton, Inc., Burbank, Calif.
J. M. Crawford, Foundry Div., Snyder Engineering Co., Los Angeles 11.
C. R. Gregg, Foundry Supt., Reliance Regulator Corp., Alhambra, Calif.
R. R. Haley, Owner, Advance Aluminum & Brass Co., Los Angeles 11.
H. W. Howell, President, Howell Foundry, Los Nietos, Calif.

Terms Expire 1948

J. B. Morey, Met., International Nickel Co. Inc., Los Angeles 15.
Roy Nash, Magnesium Alloy Products Co., Los Angeles.
Lester Rankin, Mgr., Alameda Mfg. Co., Los Angeles 11.
J. E. Wilson, Met. Engr., Climax Molybdenum Corp., Los Angeles.

Texas Chapter

(Established 1943)

Chairman—W. M. Ferguson, Works Mgr., Texas Electric Steel Casting Co., Houston 2.
Vice-Chairman—L. H. August, Foundry Engr., Hughes Tool Co., Houston 1.
Secretary-Treasurer—H. L. Wren, Manufacturers Representative, 629 M & M Bldg., Houston 2.
Directors—Terms Expire 1947

Philip Hawkins, Sec.-Treas., Texas Steel Co., Fort Worth, Texas.
W. E. Hochmuth, Supt., Houston Foundry & Machine Co., Houston.
Robert Lang, Foundry Supt., Lufkin Foundry & Machine Co., Lufkin, Texas.
W. J. Temple, Supt., Kincaid-Osborn Electric Steel Co., San Antonio, Texas.

Terms Expire 1948

W. C. Fleming, Foundry Supt., Hughes Tool Co., Houston 1, Texas.
J. O. Klein, Vice-Pres., Texas Foundries, Inc., Lufkin.

Owen Murphy, Partner, Star Foundry Co., Houston 1.
A. H. Stenzel, Owner, Stenzel Pattern Works, Houston 14.
Terms Expire 1949
G. E. Bryant, Jr., Pres., Oil City Brass Works, Beaumont, Texas.
L. N. Crim, East Texas Electric Steel Co., Longview, Texas.
R. H. Glenney, Foundry Engr., Alamo Iron Works, San Antonio, Texas.
DeWitt McKinley, Mgr., McKinley Iron Works, Fort Worth, Texas.

Toledo Chapter

(Established 1941)

Chairman—B. L. Pickett, Chief Inspector, Unitcast Corp., Toledo.
Vice-Chairman—G. R. Rusk, Sales Representative, Freeman Supply Co., Toledo.
Secretary-Treasurer—E. E. Thompson, Supt. of Pattern Dept., Unitcast Corp., Toledo.
Directors—Terms Expire 1947
R. B. Bunting, Foundry Supt., Bunting Brass & Bronze Co., Toledo.
R. T. Jansen, Supt., Plant No. 1, Unitcast Corp., Toledo.
V. E. Zang, Works Mgr., Unitcast Corp., Toledo.
Terms Expire 1948
F. E. Ensign, Ensign Foundry Co., Toledo.
L. M. Long, Consulting Engr., Leighton M. Long & Associates, Toledo.
W. P. Mack, Bruce Foundry Co., Tecumseh, Mich.
Terms Expire 1949
A. V. From, Supt., American Brake Shoe Co., Toledo.
N. P. Mahoney, Supt., Maumee Malleable Castings Co., Toledo.
Harry Schwab, Chief Met., Bunting Brass & Bronze Co., Toledo.

Twin City Chapter

(Established 1941)

Chairman—H. M. Patton, Foundry Supt., American Hoist & Derrick Co., St. Paul 1, Minn.
Vice-Chairman—S. P. Pufahl, Owner-Partner, Paul Pufahl & Son Foundry Co., Minneapolis 14.
Secretary-Treasurer—Alexis Caswell, Secy., Manufacturers' Association of Minneapolis, Inc., Minneapolis 2.
Directors—Terms Expire 1947
Clifford Anderson, President, Crown Iron Works Co., Minneapolis 13.
I. F. Cheney, Plant Supt., Griffin Wheel Co., St. Paul 6, Minn.
Herbert Larson, Foundry Supt., Minneapolis-Moline Power Implement Co., Minneapolis 1.
Terms Expire 1948
H. J. Bierman, Owner, Acme Foundry Co., Minneapolis 6.
Clifford Englund, Pattern Supt., Central Machine Works Co., Minneapolis 13.
A. M. Fulton, Vice-Pres., Northern Malleable Iron Co., St. Paul 6, Minn.
Terms Expire 1949
E. R. Frost, President, The E. R. Frost Co., Minneapolis 14.
C. C. Hitchcock, Partner, R. C. Hitchcock & Sons, Minneapolis 6.
R. C. Wood, Vice-Pres., Minneapolis Electric Steel Castings Co., Minneapolis 13.

Western Michigan Chapter

(Established 1941)

Chairman—Rudolph Flora, Met., Clover Foundry Co., Muskegon, Mich.
Vice-Chairman—C. H. Cousineau, Met., West Michigan Steel Foundry Co., Muskegon, Mich.
Secretary—V. A. Pyle, Asst. Secy., Pyle Pattern & Mfg. Co., Muskegon Heights, Mich.
Treasurer—Arthur Green, Mgr., Dake Engine Co., Grand Haven, Mich.
Directors—Terms Expire 1947
R. R. Campbell, Partner, Centrifugal Casting Co., Muskegon Heights, Mich.
J. C. Jensen, Owner, Battle Creek Foundry Co., Battle Creek, Mich.
J. W. Lee, Vice-Pres., Challenge Machinery Co., Grand Haven, Mich.
G. W. Myers, Gen. Supt., West Michigan Steel Fdry. Co.
Terms Expire 1948
C. H. Cousineau, Met., West Michigan Steel Fdry. Co.
W. R. Krepps, Plant Mgr., Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich.
A. G. Raddatz, Vice-Pres., Lakeshore Machinery & Supply Co., Muskegon, Mich.
Terms Expire 1949
O. H. Frank, Quality Research Engr., Muskegon Piston Ring Co., Sparta, Mich.
W. A. Hallberg, Foundry Engr., Lakey Foundry & Machine Co., Muskegon, Mich.
F. H. Papke, Foundry Supt., Wolverine Brass Co., Grand Rapids, Mich.

Western New York Chapter

(Established 1941)

Chairman—H. C. Winte, Met., Worthington Pump & Machinery Corp., Buffalo 5.
Vice-Chairman—E. R. Jones, Plant Supt., Lumen Bearing Co., Buffalo 12.
Secretary—L. A. Merryman, Sales Mgr., Tonawanda Iron Corp., Tonawanda, N. Y.
Treasurer—M. W. Pohlman, Vice-Pres., Pohlman Foundry Co. Inc., Buffalo 6.
Directors—Terms Expire 1947
M. S. Finley, 81 Linden Ave., Buffalo 14.
H. R. King, 1306 Delaware Ave., Buffalo 9.
H. J. Struebing, Pres., Struebing & Buchheit, Inc., Buffalo 7.
A. H. Suckow, Met., Symington-Gould Corp., Depew, N. Y.
Terms Expire 1948
J. C. Goetz, Foundry Supt., Acme Steel & Malleable Iron Works, Buffalo 7.
A. J. Heysel, Branch Mgr., E. J. Woodison Co., Buffalo 7.
F. T. McQuillin, Plant Mgr., Standard Buffalo Foundry, Inc., Buffalo 7.
Terms Expire 1949
J. C. Nagy, Chief Chemist, Chas. C. Kawin Co., Buffalo.
L. C. Smith, President, Lakeside Bronze, Inc., Buffalo 7.
J. R. Wark, Salesman, Queen City Sand & Supply Co., Buffalo 7.

Wisconsin Chapter

(Established 1935)

President—D. C. Zuege, Tech. Dir., Sivyer Steel Casting Co., Milwaukee.
Vice-President—R. J. Anderson, Works Mgr., Belle City Malleable Iron Co., Racine, Wis.
Secretary—R. C. Woodward, Chief Met. & Supt. of Foundries, Bucyrus-Erie Co., South Milwaukee.
Treasurer—R. F. Jordan, Vice-Pres., Sterling Wheelbarrow Co., Milwaukee.
Directors—Terms Expire 1947
John Bing, Dist. Mgr., A. P. Green Fire Brick Co., Milwaukee.
A. M. Fischer, Vice-Pres., Chas. Jurack Co., Milwaukee.
A. C. Haack, Vice-Pres., Wisconsin Grey Iron Foundry Co., Milwaukee.
P. F. Rice, President, Milwaukee Chaplet & Mfg. Co., Milwaukee.
Terms Expire 1948
M. A. Dantzler, Works Mgr., Rundle Mfg. Co., Milwaukee,
J. J. Ewens, Works Mgr., Grede Foundries, Inc., Milwaukee Steel Div., Milwaukee.
Terms Expire 1949
A. K. Higgins, Met. Supv., Allis-Chalmers Mfg. Co., West Allis, Wis.
C. M. Lewis, Secy-Treas., Badger Malleable & Mfg. Co., South Milwaukee.

FOUNDRY PERSONALITIES

R. C. Crouch, who joined Acme Aluminum Alloys, Inc., Dayton, Ohio, as comptroller in March of this year, has been elected a mem-

S. G. Garry **R. C. Crouch**

ber of the board of directors. Mr. Crouch also has been appointed secretary and treasurer of the firm, succeeding **W. C. Lewis,** who resigned recently after seventeen years with the firm.

S. G. Garry, associated for the past 16 years with Caterpillar Tractor Co., Peoria, Ill., and core room general foreman since 1942, has joined the company labor relations department, according to announcement by **J. R. Munro,** general factory manager. **Louis Voris,** core room supervisor, has advanced to the position of general foreman. Mr. Garry is the author of the technical paper, "Engineer of Human Relations," presented before a Foreman Training Session at the Golden Jubilee Convention and published in AMERICAN FOUNDRYMAN, February, 1946.

Tom Makemson, M.B.E., Secretary, Institute of British Foundrymen, has been released by the Ministry of Supply from the duties of Director of Iron Castings, Iron and Steel Control; but will continue to act in an advisory capacity to the Ministry.

K. H. Priestley is president, **Alfred Kunz,** vice-president, **Bradley Wellemeyer,** secretary, and **Otto Nickodemus,** treasurer, of Vassar Electroloy Products, Inc., Vassar, Mich., newly established foundry which recently entered production on its first order; 638,000 valve seat inserts for Wilcox-Rich Div., Eaton Manufacturing Co., Saginaw, Mich. All principals of the new firm were formerly associated with the Foundry Div., Eaton Mfg. Co., Vassar. Mr. Priestley is an active member of A.F.A., serving on the Steering and Executive committees, Gray Iron Division.

Dr. C. A. Nagler, formerly with the Metallography Department, University of Minnesota, Minneapolis, has moved to Wayne University, Detroit 1, as associate professor of physical metallurgy, Department of Metallurgical Engineering.

C. C. Brisbois **K. H. Priestley**

C. C. **Brisbois,** until recently superintendent, Robert Mitchell Co. Ltd., Montreal, Que., has been appointed foundry superintendent, Sorel Industries, Ltd., Sorel, Que., it has been announced by **L. D. Hudon,** general manager of the latter firm. Mr. Brisbois, who has had 32 years in the foundry industry, the last 17 with the Mitchell company, is a current Chapter Director of Eastern Canada and Newfoundland A.F.A. chapter, and served as Chapter Chairman of that group for the 1942-43 season.

G. W. Merrefield, recently works manager, Chicago Hardware Foundry Co., North Chicago, Ill., has joined Lester B. Knight & Associates, Chicago, as senior engineer. A native of Elgin, Ill., Mr. Merrefield has a background of more than thirty years foundry operating experience, and has been associated with activities of A.F.A., Gray Iron Research Institute, Steel Founders' Society, and ASM.

H. H. Judson

H. H. **Judson,** A.F.A. National Director, has left Gould Pumps, Inc., Seneca Falls, N. Y., to join Standard Foundry Co., Worcester, Mass., as foundry superintendent.

J. F. Strott and **F. E. Miick** have been elected vice-presidents of the Link-Belt Co. Pacific Div., wholly owned subsidiary of Link-Belt Co., Chicago, according to announcement of **R. H. Hoffman,** president of the division. Mr. Strott, who will have charge of sales for the West Coast, has been with the division since 1925. He will make his headquarters at the San Francisco plant. Mr. Miick, who will be located at the Los Angeles plant, joined the Link-Belt organization in 1910 and transferred to the Pacific Division in 1931. Since 1943, he has served as manager of the Los Angeles territory.

J. F. Strott **F. E. Miick**

R. E. Belt has retired as secretary, Malleable Founders' Society, Cleveland, after many years service in

(Continued on Page 98)

★ CHAPTER ACTIVITIES ★

news

Philadelphia

H. V. Witherington
H. W. Butterworth & Sons Co.
Chairman, Publicity Committee

OUTDOOR SPORTS were the order of the day for more than 400 members and guests of Philadelphia A.F.A. chapter, who gathered for the annual outing, June 29, at Hi Top Country Club, Drexel Hill, Pa. Overcast skies were no deterrent to the foundrymen as they vied for many prizes at golf, quoits and baseball.

Climaxing the day of sports was a banquet and floor show, which heightened the impression among those present that the outing was one of the most successful in chapter history. An innovation was the taking of color motion pictures of the day's activities, the films to be shown at the October meeting.

W. J. Gallana, Rogers Brown Lavino Co., Philadelphia, new chairman of the chapter entertainment committee, was in charge of arrangements for the event.

Much general discussion among members and their friends centered on the busy fall season ahead. One popular subject was the prospect of a regional foundry conference, considered as showing promise of reaching tremendous proportions.

Texas

H. L. Wren
R. Lavin & Sons, Inc.
Chapter Secretary-Treasurer

PROSPECTS FOR an unusually interesting year and a pronounced increase in membership were seen for Texas A.F.A. chapter, as chapter Directors met June 19, at Houston, with Chapter Chairman W. M. Ferguson, Texas Electric Steel Casting Co., of that city, presiding.

Chapter Vice-Chairman L. H. August, Hughes Tool Co., Houston, who serves as chairman of the chapter program committee, submitted the schedule of meetings for the coming season.

Approving the program, the board decided that all meetings will be held on Fridays, and those in Houston at the Golfcrest Country Club.

Chairman Ferguson announced that, in order to better coordinate the work of committees, he would call for reports at all Houston meetings.

Discussing methods for increasing attendance at meetings, the Directors stressed that punctuality in the opening and closing times of meetings will be the rule, as one means

Baseball, quoits, golf and general relaxation underway during Philadelphia A.F.A. chapter's annual outing, June 29, at Hi Top Country Club, Drexel Hill, Pa.

An informal gathering at Orinda Country Club, San Francisco, during Northern California A.F.A. chapter's annual ladies' night, June 28. Left to right: Chapter Secretary Fred Aicher, E. A. Wilcox Co., San Francisco; retiring Chapter President Charles Hoehn, Jr., Enterprise Engine & Foundry Co., San Francisco; A.F.A. National Director Sam Russell, Phoenix Iron Works, Oakland, Calif.; Chapter President-Elect Richard Vosbrink, Berkeley Pattern Works, Berkeley, Calif.; and Chapter Vice-President-Elect Andrew Ondreyco, Vulcan Foundry Co., Oakland.

of encouraging greater attendance. In this regard, also, Chapter Director R. H. Glenny, Alamo Iron Works, San Antonio, Texas, chairman of the publicity committee, assured the board that meeting announcements will be sent to all local papers in ample time, so as to allow foundrymen in the area to make plans for participation.

Northern California

C. R. Marshall
Chamberlain Co.
Chairman, Publicity Committee

Highlights of the annual business meeting of Northern California A.F.A. chapter, June 14, at the Engineers Club, San Francisco, were election of officers and directors, reports of committees and the report of Chapter President Charles Hoehn, Jr., Enterprise Engine & Foundry Co., San Francisco.

Reviewing the chapter activities of the past season, President Hoehn presented a series of recommendations, including establishment of a new patternmakers apprentice committee; calling of a Pacific Coast foundry conference; following up recommended "good housekeeping" steps; and recruiting of new and capable workers for the foundry. In conclusion, he expressed appreciation for the support and cooperation during his term on the part of fellow officers, committees and members.

Chapter elections resulted in naming Chapter Vice-President Richard Vosbrink, Berkeley Pattern Works, Berkeley, Calif., as *President* for the 1946-47 season.

Elected *Vice-President* was A. M. Ondreyco, Vulcan Foundry Co., Oakland, Calif., who is currently serving as a chapter Director.

Continuing as *Secretary* is J. F. Aicher, E. A. Wilcox Co., San Francisco; while C. R. Marshall, Chamberlain Co., of the same city, was named *Co-Secretary.*

J. K. Benedict, Donald Kenneth Co., San Francisco, was re-elected *Treasurer.*

Elected *Directors* were: A. C. Axford, Mission Foundry & Stove Works; Norman Barnett, M. Greenberg Sons; H. M. Donaldson, Brumley-Donaldson Co.; W. W. Clark, Enterprise Engine & Foundry Co., all of San Francisco; F. T. Williams, Empire Foundry Co., and Leon Cameto, Production Foundry Co., both of Oakland.

Guests at the business meeting included J. W. Cable, director of research, Induction Heating Corp., New York, who presented a brief discussion of "Dielectric Heating"; Bob Hannon, Beardsley & Piper Co., Chicago, a member of the Chicago A.F.A. chapter; and D. H. Grubb, Pacific Scientific Co., San Francisco.

Also included in the chapter activities for June was the annual ladies' night, held the 28th at Orinda Country Club. Members and their wives and guests turned out 122 strong for an enjoyable evening arranged by Dan Henry, Federated Metals Div., American Smelting & Refining Co., San Francisco, chairman of the entertainment committee, and his group.

One feature of the evening was the presentation to retiring President Hoehn of a gift, and a card bearing a hand-lettered expression of appreciation for his work during the past chapter season.

Mexico City

N. S. Covacevich
Casa Covacevich Foundry Supplies & Equipment
Chapter Secretary

Official headquarters for the Mexico City A.F.A. chapter have been established at Barcelona 11, where office space has been acquired. Meetings will be held and a chapter library located in the new quarters, which also will serve as a center for other local activities of foundrymen.

At the chapter meeting of August 2, Ingeniero Ortega Varela, Com-

Some of the 122 members, wives and guests at Orinda Country Club, San Francisco, June 28, for Northern California A.F.A. chapter's annual ladies' night.

mission Federal Electrical, Villa Obregon, presented a report of his trip to the Golden Jubilee Convention at Cleveland.

These past presidents of Northern California A.F.A. chapter were on hand to enjoy the program for annual ladies' night, June 28, at Orinda Country Club, San Francisco. Left to right: Ralph Noah, San Francisco Iron Foundry, Inc., San Francisco; Edward Welch, American Manganese Steel Div., Oakland, Calif.; Charles Hoehn, Sr., Enterprise Engine & Foundry Co., San Francisco; and A.F.A. National Director Sam Russell, Phoenix Iron Works, Oakland.

Chicago

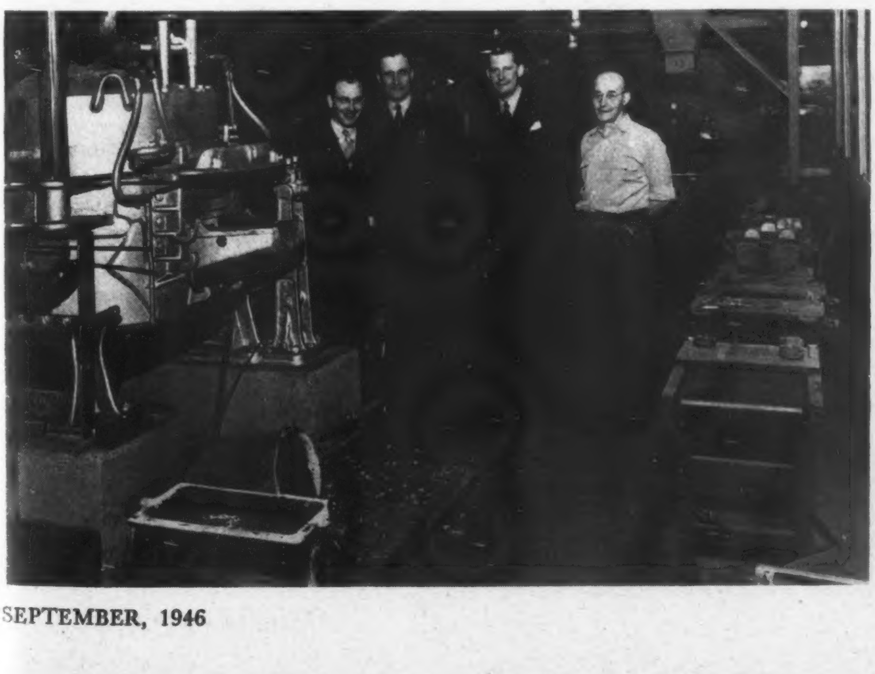
SCHEDULING a general session of all divisions on core blowing and establishing an opportunity for out-of-town registrants to see the foundry exhibit at the Museum of Science and Industry in Jackson Park, the arrangements committee for the Chicago Regional Foundry Conference put near-final touches on the schedule of conference activities at its Aug. 12 meeting. The conference is to be held Nov. 21-22 at the Continental Hotel, Chicago.

Two special heats will be poured Saturday morning, Nov. 23, following the close of the conference, for the special benefit of foundrymen visiting the Museum to see the foundry exhibit. Maintained jointly by Chicago A.F.A. chapter and the National Office the foundry operates, normally, on a five day week schedule. Admission will be limited to the conference group. A. W. Gregg, Whiting Corp., Harvey, Ill., chairman of the arrangement committee, announced the plans.

The general conference meeting on core blowing, which had been included in both steel and pattern programs, will be held on the afternoon of Friday, Nov. 22. Scheduled as speakers for the session are: A. W. Magnuson, Champion Foundry & Machine Co., Chicago, on sands for core blowing; Zigmond Madacey, Caterpillar Tractor Co., Peoria, Ill., on pattern equipment for core blowing; and L. D. Pridmore, International Molding Machine Co., Chicago, who will discuss core blowing equipment.

Other additions to the list of outstanding speakers who will address the foundrymen are V. J. Sedlon, Master Pattern Co., Cleveland, Vice-Chairman of the A.F.A. Patternmaking Division; and A. C. Den Breejen, Hydro-Blast Corp., Chicago, popular speaker on sand technology before many A.F.A. chapters and author of several technical papers which have appeared in AMERICAN FOUNDRYMAN.

Foreign foundrymen, left to right: E. O. Lissell, Swedish Ass'n of Machine Shops and Foundries, Stockholm, Sweden; J. Sissener, Myrens, M. V. Oslo, Norway; and T. Forslund, A. B. Swenska Kullagerfabriken, Katrineholm, Sweden, with Alex Dapogney, museum representative in charge, during recent visit to the operating foundry exhibit at the Museum of Science and Industry, Chicago. Exhibit is open to the public five days a week, and is maintained jointly by the A.F.A. National Office and the Chicago chapter.



Non-Ferrous Founders' Society

H. J. Evans
Assistant Secretary-Treasurer

FIRST ANNUAL GOLF TOURNAMENT of the Chicago chapter, Non-Ferrous Founders' Society, July 12, at Itasca Country Club, Itasca, Ill., brought approximately 60 members and guests onto the greens and fairways; and 92 were on hand for the evening banquet, with Grant Roth, Ace Foundry Co., Chicago, chairman of the chapter, serving as toastmaster.

Arrangements for the occasion, which was considered the highlight of the season, were handled by entertainment chairman Walter Hunter, Hunter Foundry Co., Chicago, and his committee. Representing the national organization were two Society directors: C. K. Faunt, Christensen & Olsen Foundry Co., Chicago, and Fred Haack, Jr., Capital Brass & Aluminum Foundry, of the same city.

CHAPTER MEETINGS

SEPTEMBER-OCTOBER

September 16

Quad City

Fort Armstrong Hotel
Rock Island, Ill.
ROUND TABLE MEETING

September 19

Twin City

Curtis Hotel, Minneapolis
LESTER B. KNIGHT
Lester B. Knight & Associates
Good Housekeeping in the Foundry

Oregon

Heathman Hotel, Portland
V. E. BELUSKO
Electric Steel Foundry
C. M. HOLMES
Crawford & Doherty Foundry Co.
Sand Testing and Control

September 20

Southern California

Roger Young Auditorium
H. M. RUTLEDGE
National Carbon Co.
Carbon and Graphite in the Foundry

September 21

Michiana

Elkhart Country Club, Elkhart, Ind.
STAG OUTING

September 23

Northwestern Pennsylvania

Moose Club, Erie
C. E. WESTOVER
Westover Engineers
Cost Control and Job Evaluation

September 27

Chesapeake

Engineers Club, Baltimore, Md.
S. C. MASSARI
American Foundrymen's Association
Engineering Properties of Cast Iron

REGIONAL CONFERENCE
September 27-28
Eastern Canada-Newfoundland
Charlottetown, Prince Edward Island
Hotel Charlottetown

Texas

Golfcrest Country Club, Houston
C. R. MCGRAIL
Texaloy Foundry Co.
High Test Gray Iron

October 1

Michiana

Hotel Whitcomb, St. Joseph, Mich.
LAWRENCE PRIDMORE
International Molding Machine Co.
Core Blowing

October 3

Saginaw Valley

Fischer's Hotel, Frankenmuth, Mich.
B. L. SIMPSON
National Engineering Co.
History of the Foundry Industry

October 7

Chicago

Chicago Bar Association
PAST CHAIRMAN NIGHT

Central Illinois

Jefferson Hotel, Peoria
MAX KUNIANSKY
Lynchburg Foundry Co.
Foundry Control

October 11

Eastern Canada-Newfoundland

Mount Royal Hotel, Montreal, Que.

October 14

Cincinnati District

Cincinnati Milling Machine Co.
PLANT VISITATION

October 18

Birmingham District

Tutwiler Hotel
W. W. LEVI
Lynchburg Foundry Co.
Cupola Operations and Control

October 25

Texas

Golfcrest Country Club, Houston
ROUND TABLE DISCUSSION

ABSTRACTS

NOTE: The following references to articles dealing with the many phases of the foundry industry, have been prepared by the staff of *American Foundryman*, from current technical and trade publications.

When copies of the complete articles are desired, photostat copies may be obtained from the Engineering Societies Library, 29 W. 39th St., New York, N. Y.

Aluminum-Base Alloys

GASES. Eastwood, L. W., *"The Theory of Gases in Aluminum,"* LIGHT METAL AGE, January, 1946, vol. 4, no. 1, pp. 10-11.

A discussion of the physical, chemical, and mathematical laws involved in the absorption and diffusion of gases in aluminum.

Brass and Bronze

CHILL CAST. Winterton, K., *"Fracture Characteristics,"* METAL INDUSTRY, March 22, 1946, vol. 68, no. 12, pp. 223-226.

By examination of fractures in chill cast bronzes, important information can be obtained as to unsoundness due to gas porosity, shrinkage porosity and inclusions. The author has correlated fracture types with mechanical properties and lists them in the order of merit.

Included in the article is an excellent color plate showing the fracture characteristics of various chill cast bronzes.

MECHANICAL PROPERTIES. Winterton, K., *"Phosphorus-Bronze,"* METAL INDUSTRY, January 11, 1946, vol. 68, no. 2, pp. 23-26.

Tensile properties, hardness, and density of chill-cast phosphorus-tin bronzes prepared by the flux-degassing process and slowly poured. Microstructures were studied, and the relations between constitution and mechanical properties are discussed.

PROPERTIES VS. STRUCTURE. Pell-Walpole, W. T., *"Chill Cast Bronzes,"* METAL INDUSTRY, April 19, 1946, vol. 68, no. 16, pp. 303-305.

A description of various types of porosity commonly encountered in the foundry; the cause, nature and appearance of entrapped gas, shrinkage and soluble gas porosity.

Centrifugal Casting

MAGNESIUM-BASE ALLOYS. Strieter, F. P., and Maenner, R. J., *"Centrifugal Casting of a Magnesium Part,"* AMERICAN FOUNDRYMAN, May, 1946, vol. 9, no. 5, pp. 43-47.

A magnesium part which ordinarily was cast in permanent molds was made experimentally by centrifugal casting. The author describes the results obtained and discusses the problems peculiar to the centrifugal casting of light metal alloys.

Chemical Analysis

STEEL. Johnson, C. M., *"Determination of Tungsten and Columbium in Stainless Steels,"* THE IRON AGE, April 11, 1946, vol. 157, no. 15, pp. 66-68.

The determination of tungsten and columbium together in stainless steels containing titanium, molybdenum, and about 18 per cent chromium and 10 per cent nickel.

Cores

MALLEABLE. Zirzow, E. C., *"Malleable Core Making Practice,"* AMERICAN FOUNDRYMAN, May, 1946, vol. 9, no. 5, pp. 35.

A brief summary of general coreroom practice in the malleable foundry in which the author is employed.

The author shows that it is possible to control core sand mixtures. Although there are many variables in the making and processing of cores, many of these variables can be controlled in simple ways.

The author has stressed the importance of the gas content test, not only from the standpoint of producing sound castings but also as a check on coreroom practice.

Gray Cast Iron

CHILL INDUCER. *"Some Initial Results on the Influence of Tellurium as a Chill-Inducing Medium in Cast Iron,"* FOUNDRY TRADE JOURNAL, March 14, 1946, vol. 78, no. 1543, pp. 283-287.

Tellurium for the purpose of inducing chill may be applied as a direct addition to the ladle, as a mold wash suspended in a suitable vehicle, and mixed with facing sand and rammed in light depth over the area to be chilled.

CRANKSHAFTS. Johnstone, George, *"Moulding Large Meehanite Crankshafts,"* FOUNDRY TRADE JOURNAL, March 7, 1946, vol. 78, no. 1542, pp. 261-264.

Vertical pouring and cooling; horizontal pouring and vertical cooling; horizontal pouring and horizontal cooling; details of foundry practice; and structural durability.

HIGH STRENGTH. Horton, A. H., *"Some Notes on High-Duty Cast Irons,"* FOUNDRY TRADE JOURNAL, February 14, 1946, vol. 78, no. 1539, pp. 169-171.

Probably the greatest cause of failure in high-duty cast irons is the lack of shock resistance in castings made to replace steel parts. Such castings are made of iron with such a low carbon content that severe casting stresses may be set up on cooling and probably should be relieved by a simple anneal. The carbon content, aided by alloy content controls the graphite structure of the casting, which, in turn, determines the properties of the casting.

MILL ROLLS. Murton, O. E., *"Roll Manufacture,"* IRON AND STEEL, March, 1946, vol. 19, no. 3, pp. 97-101.

Types of rolls in common use in American rolling mill practice, methods of manufacture, and conditions which influence their application.

PRESSURE CASTINGS. Brown, R. H., *"Duplex Pump Castings,"* FOUNDRY TRADE JOURNAL, February 28, 1946, vol. 78, no. 1541, pp. 223-233.

Layout and plant; melting equipment; sand plant; mold washes; laboratory and shop tests; types of castings produced; steam cylinders; air exit off parts; complicated core assembly; gunmetal valve plates; bronze cylinder castings; valve box castings; and light pump castings.

SPECTROSCOPIC ANALYSIS. Hurst, J. E., and Riley, R. V., *"Routine Spectrographic Analysis of Cast Iron,"* THE IRON AND STEEL INSTITUTE, Advance Copy, June, 1946, 12 pp.

A description of a method for routine spectrographic analysis of cast iron.

SULPHUR. Brown, E. S., *"Sulphur, Effects in Cast Iron and Steel,"* IRON AND STEEL, February, 1946, vol. 19, no. 2, pp. 71-74.

Sulphur affinities, sulphur eutectics, sulphur in cast iron, sulphur in steel, strength at high temperatures, desulphurizing with sodium carbonate, effect of lining, and effect of sodium carbonate treatment on cast iron.

Inspection

FLUOROSCOPIC. Cassen, B., and Clark, D. S., *"Fluoroscopy of Light Alloy Castings,"* THE IRON AGE, April 18, 1946, vol. 157, no. 16, pp. 48-50.

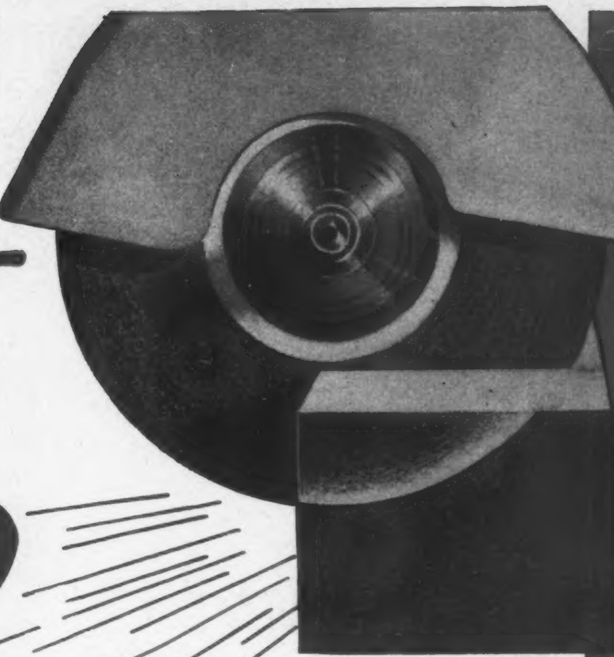
The author covers the significance of observed defects on usability of castings and the use of higher X-ray voltages to obtain greater screen brightness. He also discusses the examination of steel castings at voltages from 140 kv. to 200 kv.

METHODS. Cook, T., *"Inspection in a Mechanized Foundry,"* FOUNDRY TRADE JOURNAL, February 7, 1946, vol. 78, no. 1538, pp. 133-145.

A detailed account of the manner in which inspection of castings serves as a factor in mass production. Inspection is performed to check two things—dimensional accuracy and quality. Emphasis is placed on the need for checking all pattern equipment before releasing it for production use.

(Concluded on Page 108)

Electro HIGH SPEED CUT-OFF WHEELS



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HIGHSPEED STEEL

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BRASS

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Foundry Personalities

(Continued from Page 90)

that capacity. A graduate of Ohio Northern University, Ada, Ohio, Mr. Belt entered Law School at National University, Washington, D. C., where he was awarded an LL.B. degree; and he later qualified as a certified public accountant.

He became secretary of the trade group, then known as American Malleable Castings Association, 30 years ago, and has been continuously active within the foundry industry since. Author of the book, "Foundry Cost Accounting," Mr. Belt also has contributed many papers to technical publications and meetings. He has played an active part in a number of A.F.A. activities, especially in connection with the A.F.A. Foundry Cost Committee.

T. J. Owen, for many years associated with the Cleveland headquarters office of the Gray Iron Founders' Society, has joined the National Founders Association, Chicago, as eastern representative with headquarters in New York.

E. M. Allen, since 1934 chairman of the board of directors, Mathieson Alkali Works, Inc., New York, has resigned that position. He will continue to serve as a director of the company. Mr. Allen joined the Mathieson firm as president in 1919, and continued in that capacity until 1944.

G. T. Lundberg, supervisor of transmission design, engineering department, Caterpillar Tractor Co., Peoria, Ill., has been named assistant to **H. S. Eberhard,** company vice-president in charge of manufacturing, engineering, research and training. **N. E. Risk** has assumed supervision of transmission design.

W. B. Weiss, recently discharged from military service, has been elected president, and **R. C. Anderson,** previously associated with South Chicago Works, Republic Steel Corp., Chicago, has been named vice-president, of Weiss Steel Co. Inc., Chicago. The reorganized

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Foundry Personalities

(Continued from Page 98)

firm was formerly a partnership. Other company officials are: **J. F. Walsh,** secretary; **J. I. Weiss,** treasurer; and **I. S. Toplon,** general counsel.

W. C. Kerrigan, since 1933 assistant manager, nickel sales department, International Nickel Co., New York, has been appointed manager of that department, succeeding the late **R. L. Suhl.** Mr. Kerrigan has been with the firm since 1930.

M. R. Woodward, for the past four years chief engineer, Plum Brook Ordnance Works, Sandusky, Ohio, has rejoined Vulcan Iron Works, Wilkes-Barre, Pa., as director of the newly established cement, lime and allied products division. **L. D. Holden,** associated as design engineer with Lehigh Portland Cement Co., Allentown, Pa., for 18 years, has joined the Vulcan firm as assistant to Mr. Woodward.

A. D. Schwope, formerly associated with Wright Aeronautical Corp., Paterson, N. J., has been appointed to the staff of Battelle Memorial Institute, Columbus, Ohio; and will be engaged in research on engineering properties of materials.

E. S. Thompson has joined Farrel-Birmingham Co. Inc., Ansonia, Conn., as a member of the rubber and plastic machinery sales staff.

L. F. Wartman, G. R. Wlodyga, Richard Kirchmayer and **J. R. Karpowitz** are principals as, respectively, president, vice-president, secretary, and treasurer and director of research, in formation of the new firm, Austin Gray Iron Foundry, Sheboygan, Wis.

George Johnstone, foundry superintendent, Cooper-Bessemer Corp., Grove City, Pa., has resigned that position to serve as president and general manager of the reorganized

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Foundry Personalities

(Continued from Page 100)

Lawrence Foundry Co., Grove City. Mr. Johnstone is an active member of A.F.A. and was recently elected a Director of Northwestern Pennsylvania A.F.A. chapter.

Obituaries

Louis J. Desparois, district sales manager for Pickands, Mather & Company, St. Louis, Missouri, died on July 25 of a heart ailment.

Mr. Desparois, associated with the foundry industry for more than 30 years, was an active member of the St. Louis District A.F.A. chapter, having served as an officer of that group and on many of its committees. A native of Detroit, he received his early schooling there, and later attended college in France and in Kansas City, Mo. He began his foundry career with American Radiator Co., St. Louis, as an apprentice foreman. Mr. Desparois joined Pickands, Mather & Co. in 1935.

L. J. Desparois

Ralph H. West, president and chairman of the board, West Steel Casting Co., Cleveland, died August 21 at his home in Wickliffe, Ohio. Mr. West founded the West Steel Casting Co. in 1907, and had served as its president since that time.

One of Cleveland's leading foundrymen, Mr. West was a member of A.F.A., ASME, Steel Founders' Society and National Founders Association, and had served on the Executive Committee of the A.F.A. Steel Division. He was the son of Thomas D. West, one of the earliest members of A.F.A. and National President of the Association for 1905-06.

R. H. West

C. H. McCrea

Charles H. McCrea, president and director, National Malleable & Steel Castings Co., Cleveland, died suddenly August 24 after suffering a stroke.

Mr. McCrea, who had been president of the company since 1942, spent virtually his entire business career with that organization, joining at Toledo in 1913. A native of Logansport, Ind., he had graduated from Purdue University, Lafayette, Ind., the preceding year.

Considered an outstanding authority in the foundry industry, Mr. McCrea was a member of the Northeastern Ohio A.F.A. chapter, a past trustee of the Malleable Founders' Society and a member of the Steel Founders' Society.

Firm Facts

Link-Belt Co., Chicago, has opened new sales offices at Birmingham, Ala., and Cincinnati: Comer Building, 2100 Second Ave., N., Birmingham 3, and 730 Temple Bar Building, Main and Court St., Cincinnati.

Castalloy Co. Inc., Cambridge, Mass., has placed in operation, at 363 Third St., a new foundry, designed for volume production of aluminum and magnesium permanent mold castings.

Erratum—AMERICAN FOUNDRYMAN regrets publication in the April, 1946, Pre-Convention issue of an erroneous report that **Nock Fire Brick Co.**, Cleveland, had changed the firm name to **Nock & Sons Co.** There has been no change in the name or operations of either firm, the former founded in 1912, and the latter in 1943.

Allis-Chalmers Mfg. Co., Milwaukee, announces installation of improved testing and laboratory facilities for a variety of industrial and marine products. Included are a new "shock-test" laboratory developed in co-operation with the Navy during the war, a new electronic processing laboratory and a new steam turbine auxiliary test floor.

Operations of the **Lead Products Div., American Smelting & Refining Co.**, New York, have been consolidated with those of the **Federated Metals Div.** of the firm. A. P. Knapp, for the last six years general manager of the Lead Products Div. and president of its subsidiary, **Andrews Lead Construction Co.**, will acquire operations of the subsidiary and certain of the facilities and business of the division; and will operate through two newly-formed companies of which he is president, **Andrews-Knapp Construction Co.**, and **Knapp Mills, Inc.**, both with offices at 120 Broadway, New York.

Doubling postwar expansion plans previously announced, **National Gypsum Co.**, Buffalo, N. Y., has launched a sixteen and one-half

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Firm Facts

(Continued from Page 105)

million dollar program. Funds will go into existing facilities at Clarence Center, N. Y., Baltimore, Md., and Kimballton, Va., as well as construction on sites at Birmingham and Mobile, Ala., and elsewhere.

Establishment of **Inland Gray Iron Foundry, Inc.,** Watertown, Wis., with capital investment of $25,000, has been announced by the principals: J. H. Budde, Sr., J. H. Budde, Jr., and F. C. Gerlach.

Champion Foundry & Machine Co., Chicago, has announced purchase of a one-story building of 40,000 sq. ft. floor space, in North Rockford, Ill. The structure will be equipped and operated as a branch in production of the firm's core-blowing and molding machines.

Installation of more than 7,000 feet of power conveyors, new shake-out equipment, a ventilating system to improve working and health conditions, shot blasting equipment and a large heat treat furnace, are included in a modernization program undertaken by **Lakey Foundry & Machine Co.,** Muskegon, Mich.

Central Foundry Div., General Motors Corp., Lockport, N. Y., has been established to provide additional foundry service for other divisions of the corporation, and has taken over the gray iron foundry previously operated by the **Harrison Radiator Div.** at Lockport. S. W. Healy, formerly works manager, **Saginaw Malleable Iron Div.,** Saginaw, Mich., has been named general manager of the Central Foundry organization.

Erie Casting Co., 16th and German Streets, Erie, Pa., is a new gray iron foundry scheduled to begin production in the immediate future.

Removal of the plant of **The Coremakers, Inc.,** from 1811 Carroll Ave., Chicago 12, to 4435 W. Division St., Chicago 55, has been announced by E. I. Schumm, president of the firm. New modern equipment has been installed to double the capacity of company facilities.

Abstracts

(Continued from Page 95)

Magnesium-Base Alloys

DESIGN AND CASTINGS. McDowall, C. J., *"Design of Magnesium Castings for High Properties and Soundness,"* PRODUCT ENGINEERING, April, 1946, vol. 17, no. 4, pp. 340-343.

Proportions, properties and basic factors that must be considered to assure desired strength and stiffness and sound castings.

HEAT TREATMENT. Thomson, R. F., Banks, D. B., and Jominy, W. E., *"Effect of Water Vapor on Magnesium Alloys During Heat Treatment,"* METAL PROGRESS, July, 1946, vol. 50, no. 1, pp. 67-71.

Tests performed by heat treating a magnesium-base alloy in humidified atmospheres indicated that water vapor at 730° F. is detrimental; SO_2 has a definite inhibiting effect on burning in amounts as small as 0.6 per cent.

Metallurgy

SOLIDIFICATION. Ruddle, R. W., *"The Feeding of Castings,"* FOUNDRY TRADE JOURNAL, March 7, 1946, vol. 78, no. 1542, pp. 253-257.

Sectional variations; shrinkage defects; effect of pouring temperature on shrinkage; steel castings; correct feeding essentials; the Williams system of feeding.

Particle Size

DETERMINATION. Bailey, Emerson D., *"Particle Size by Spectral Transmission,"* INDUSTRIAL AND ENGINEERING CHEMISTRY, Analytical Edition, June, 1946, vol. 18, no. 6, pp. 365-370.

A simple method has been developed for determining two-parameter size distributions from transmissions measured in the visible and near infrared parts of the spectrum. It is based on an empirical relationship between scattering, particle size, refractive index, and the wave length of light. The method was developed for essentially nonabsorbing materials and was originally based on particle size measurements made with the low-speed Svedburg ultracentrifuge.

DETERMINATION. Jacobsen, A. E., and Sullivan, W. F., *"Centrifugal Sedimentation Method for Particle Size Distribution,"* INDUSTRIAL AND ENGINEERING CHEMISTRY, Analytical Edition, June, 1946, vol. 18, no. 6, pp. 360-364.

The centrifugal sedimentation method for particle size distribution of materials in a dispersed system is reviewed. A preferred method has been used which is analogous to Odin's method of tangential intercepts for gravitational sedimentation. This procedure yields the same results as those obtained by the variable suspension height method but is more convenient from the practical point of view. Examples are given to show practical applications of the beaker type centrifuge to the study of relative dispersion of titanium dioxide pigment in paint systems. The method is of limited usefulness for the determination of specific surface area or the relative efficiency of light-diffusing properties of materials which are either aggregated or irregularly shaped, since Stokes' law is based on the assumption of an equivalent spherical particle. Electron micrographs supplement the sedimentation studies.

Precision Casting

METHODS. *"Precision Casting Practice,"* STEEL, February 4, 1946, vol. 118, no. 5, pp. 128-9, 166, 168, 170.

Elimination of wax pattern by heat, casting of metal, solidification of metal, and factors which may determine success or failure in production operations.

PRODUCTION METHODS. *"Mass Production of Precision Castings,"* STEEL, April 8, 1946, vol. 118, no. 14, pp. 96-100, 102, 104, 106.

A description of the production line setup at Haynes Stellite Co., Kokomo, Ind.

Testing

FLUIDITY. Taylor, G. B., *"Rapid Test for Fluidity Measurement,"* THE IRON AGE, April 11, 1946, vol. 157, no. 15, pp. 62-63.

A modification of the standard fluidity test, designed to simplify the making of the spiral mold and to eliminate undesirable time lag in obtaining a reading.